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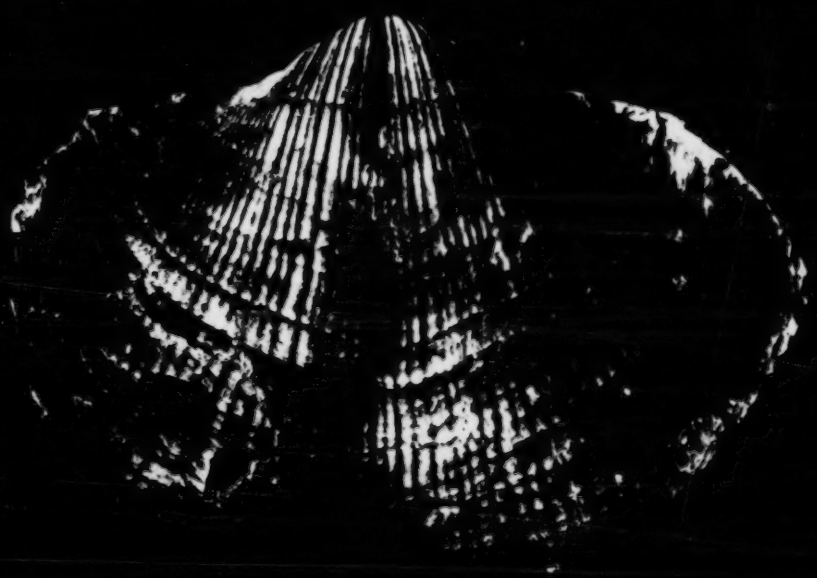
LOWER CARBONIFEROUS BRACHIOPODS FROM THE BANFF FORMATION OF WESTERN ALBERTA



J.L. Carter

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PREFACE

Investigations of well exposed Lower Carboniferous sedimentary rocks in the eastern Cordillera of Alberta and British Columbia provide important geological information for use in the exploration of correlative, petroleum-bearing strata in the adjacent subsurface to the east. This report presents the systematic descriptions, biostratigraphic distribution and paleogeographic significance of brachiopod faunas from the Tournaisian Banff Formation. Eighty-seven species assigned to fifty-three genera are described and illustrated. Three brachiopod zones are established and correlated with standard successions in the United States and Eurasia.

Biostratigraphic and taxonomic studies of this kind provide detailed data necessary for an understanding of the depositional and tectonic history of the Western Canada Sedimentary Basin, and thereby contribute to the estimation and definition of mineral and energy resources in Canada.

R.A. Price
Assistant Deputy Minister
Geological Survey of Canada

PRÉFACE

L'étude de bons affleurements de roches sédimentaires du Carbonifère inférieur, dans l'est de la Cordillère de l'Alberta et de la Colombie-Britannique, nous a fourni des renseignements géologiques importants pour l'exploration de strates pétrolifères de la subsurface adjacente, situées à l'est et pouvant être corrélées avec les premières. Dans ce rapport, on donne des descriptions systématiques, on présente les distributions biostratigraphiques, et l'on explique l'importance paléogéographique des faunes de brachiopodes de la formation de Banff du Tournaisien. On décrit et on illustre quatre-vingt sept espèces placées dans cinquante-trois genres. On définit trois zones à brachiopodes, et l'on établit une corrélation avec des successions standard des États-Unis et d'Eurasie.

Ce genre d'études biostratigraphiques et taxonomiques nous fournit les données détaillées dont nous avons besoin pour mieux comprendre l'évolution sédimentaire et tectonique du Bassin sédimentaire de l'Ouest du Canada, et nous aide ainsi à estimer et à définir les ressources minérales et énergétiques du Canada.

R.A. Price, sous-ministre adjoint,
Commission géologique du Canada

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LOWER CARBONIFEROUS BRACHIOPODS FROM THE BANFF FORMATION OF WESTERN ALBERTA

Abstract

Brachiopods are the most common as well as the most diverse megafossils in the Banff Formation of western Alberta. Eighty-seven species assigned to fifty-three genera are identified from over 6900 specimens in the collections of the Geological Survey of Canada.

Two new genera, one new subgenus, and twenty-four new species are described. The new genera are: the productacean, *Piloricilla*, type species *P. desmetensis* n. sp., and the spiriferacean, *Calvustrigis*, type species *C. rutherfordi* (Warren). The productacean *Seminucella*, type species *S. parva* n. sp., is proposed as a subgenus of *Spinocarinifera* Roberts. Other new species are: *Subglobosochonetes norquayensis*, *Plicochonetes canadensis*, *Spinocarinifera copiosa*, *Rugauris robusta*, *Avonia banffensis*, *Avonia canyonensis*, *Avonia? beckerensis*, *Stegacanthia gausapa*, *Pustula morrocreekensis*, *Ovatia prolata*, *Moorefieldella prisca*, *Macropotamorhynchus insolitus*, *Macropotamorhynchus curiosus*, *Shumardella pygmaea*, *Cleiothyridina harkeri*, *Cleiothyridina miettensis*, *Composita prolixa*, *Prospira fessaulacis*, *Spirifer mountraensis*, *Skelidorygma bamberi*, *Torynifer eufastigium*, and *Verkhotomia fucunda*.

The stratigraphic distribution of the brachiopods makes possible the recognition of three brachiopod zones in the megafossil-bearing beds of the middle and upper Banff Formation. In ascending order these are: the *Calvustrigis rutherfordi*, *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis*, and *Avonia minnewankensis-Marginatia burlingtonensis* zones.

The *Calvustrigis rutherfordi* Zone can be correlated with the Gilmore City Limestone of north-central Iowa, but represents an interval of time between the Kinderhookian and Osagean not recorded in the upper Mississippi Valley standard section. The *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone can be correlated with the lower Osagean Meppen-Fern Glen-lower Burlington-Pierson strata of Missouri and the Mississippi Valley region. The *Avonia minnewankensis-Marginatia burlingtonensis* Zone correlates approximately with the Burlington Limestone at its type section in southeastern Iowa.

The Banff brachiopod fauna has notable affinities with the fauna of the largely undescribed Lodgepole Formation of Montana and Wyoming, but accurate correlations with the latter are not possible at present. The only overseas faunal affinites are with the Tournaisian faunas of the Kuznets Basin in southwestern Siberia and southeastern Kazakhstan.

Résumé

Les brachiopodes sont les mégafossiles les plus courants en même temps que les plus diversifiés de la formation de Banff dans l'ouest de l'Alberta. On a identifié quatre-vingt sept espèces que l'on a placées dans cinquante-trois genres, en analysant 6900 spécimens provenant des collections de la Commission géologique du Canada.

Dans ce rapport, on décrit deux nouveaux genres, un nouveau sous-genre et vingt-quatre nouvelles espèces. Les nouveaux genres sont: le productacé *Piloricilla*, de l'espèce type *P. desmetensis* n. sp., et le spiriféracé *Calvustrigis*, de l'espèce type *C. rutherfordi* (Warren). Le productacé *Seminucella*, de l'espèce type *S. parva* n. sp. est proposé comme sous-genre de *Spinocarinifera* Roberts. Parmi les nouvelles espèces figurent: *Subglobosochonetes norquayensis*, *Plicochonetes canadensis*, *Spinocarinifera copiosa*, *Rugauris robusta*, *Avonia banffensis*, *Avonia canyonensis*, *Avonia? beckerensis*, *Stegacanthia gausapa*, *Pustula morrocreekensis*, *Ovatia prolata*, *Moorefieldella prisca*, *Macropotamorhynchus insolitus*, *Macropotamorhynchus curiosus*, *Shumardella pygmaea*, *Cleiothyridina harkeri*, *Cleiothyridina miettensis*, *Composita prolixa*, *Prospira fessaulacis*, *Spirifer mountraensis*, *Skelidorygma bamberi*, *Torynifer eufastigium*, et *Verkhotomia fucunda*.

La distribution stratigraphique des brachiopodes nous permet d'identifier trois zones à brachiopodes dans les lits à mégafossiles des niveaux intermédiaire et supérieur de la formation de Banff. Suivant un ordre ascendant ce sont: la zone à *Calvustrigis rutherfordi*, la zone à *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis*, et la zone à *Avonia minnewankensis-Marginatia burlingtonensis*.

On peut établir une corrélation entre la zone à *Calvustrigis rutherfordi* et les calcaires de Gilmore City dans la partie nord-centrale de l'Iowa, mais cette zone représente un intervalle de temps compris entre le Kinderhookien et l'Osagéen, qui n'a pas encore été répertorié à la partie supérieure de la coupe type de la vallée du Mississippi. On peut corréler la zone à *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* avec les strates de Meppen-Fern Glen (Osagéen inférieur) - du Burlingtonien inférieur - de Pierson, dans le Missouri et la région de la vallée du Mississippi. On peut établir une corrélation approximative entre la zone à *Avonia minnewankensis-Marginatia burlingtonensis* et le calcaire de Burlington, à l'emplacement de la coupe type de celui-ci, dans le sud-est de l'Iowa.

Le faune de brachiopodes de Banff présente des affinités nettes avec la faune de la formation de Lodgepole dans le Montana et le Wyoming, jusque-là très peu décrite, mais il n'est pas possible actuellement d'établir des corrélations précises avec cette dernière. Les seules affinités avec des faunes d'outre-mer sont celles observées avec les faunes tournaisiennes du bassin du Kuznets, dans le sud-ouest de la Sibérie et le sud-est du Kazakhstan.

Summary

This is the first major monograph on brachiopods from the Banff Formation of western Alberta. The fauna described is diverse, consisting of representatives of the following groups: punctate orthids, strophomenids, orthotetids, chonetids, productids, rhynchonellids, retziids, athyridids, impunctate spiriferids, punctate spiriferids and terebratulids. Two new genera, one new subgenus and twenty-four new species are described.

The Banff Formation comprises three, informal unnamed members. The "lower" member is barren, except for conodonts and rare, inarticulate brachiopods. Some beds in the "middle" and "upper" members contain reasonably numerous megafossils, particularly in the "eastern" facies, but continuously fossiliferous sequences are not known at any single stratigraphic section. Therefore a biostratigraphic subdivision of the Banff Formation based on megafossils must be assembled from distribution data from several stratigraphic sections.

Macqueen and Bamber (1967) proposed a correlation between the Pekisko and Shunda formations of the Alberta Foothills and Jasper region (their "eastern" facies) and the Lower Mississippian formations of the Bow River valley and Rocky Mountains to the south (their "western" facies). The true chronological relationship between these facies remains uncertain, but the terms "eastern" and "western" facies are used in this study. In general there are distinct differences between the faunas in the "eastern" and the "western" facies. A strong similarity between "eastern" and "western" faunas exists only in the lowest of the three brachiopod zones listed below.

Three biostratigraphic zones based on distribution data from 181 collecting localities are established in this study. In ascending stratigraphic order these are: the *Calvustrigis rutherfordi* Zone, the *Stegacanthia* cf. *S. bowsheri-Marginatia ferrnglenensis* Zone, and the *Avonia minnewankensis-Marginatia burlingtonensis* Zone.

The *Calvustrigis rutherfordi* Zone is approximately equivalent to the *Platyrachella rutherfordi* Zone proposed by Nelson (1961) for the "middle" member of the type Banff Formation and the "upper" member of the Banff in the Jasper region. The fauna of this zone is very large, consisting of 73 of the 87 Banff species described here. Of this number, 71 species are found in the "eastern" facies and 28 in the "western" facies fauna. Of the 73 species found in this zone, 48 are restricted to it making it a useful biostratigraphic unit. Brachiopods from this zone occur only in the "middle" member. The lowest fossiliferous beds in the "upper" member contain several species that mark the overlying *Stegacanthia* cf. *S. bowsheri-Marginatia ferrnglenensis* Zone.

The lower boundary of the *Stegacanthia* cf. *S. bowsheri* Zone is delimited by the lowest occurrence of three key species. In addition, several other species make their first appearance in the lower part of the zone. In the Bow River valley region, this zone occupies approximately the lower 200 ft (60 m) of the "upper" member.

The *Avonia minnewankensis-Marginatia burlingtonensis* Zone is named after two very distinctive and easily recognized productids. The zone occupies approximately the upper 350 to 400 ft (105 to 120 m) of the "upper" member of the Banff Formation and the lower 100 to 150 ft (30 to 45 m) of the overlying Livingstone Formation. In the Bow River valley region of the western facies, megafossils are very rare above this zone in the Livingstone Formation.

The Banff Formation is correlated with the standard section of the Mississippian System in the mid-continent. Comparison of the Banff fauna with the brachiopod fauna from the Gilmore City Limestone of north-central Iowa shows that 86 per cent of the brachiopod genera in the latter fauna also occur in the *Calvustrigis* assemblages of Alberta and that most of the species are identical or have close analogues. The two "upper" Banff brachiopod zones of this report are clearly Osagean in age. The *Stegacanthia* cf. *S. bowsheri-Marginatia ferrnglenensis* Range Zone correlates readily with the Meppen, Fern Glen, lower Burlington, and Pierson formations of Missouri. This zone is missing in its entirety in southeastern Iowa.

The upper limits of the youngest Banff brachiopod zone, the *Avonia minnewankensis-Marginatia burlingtonensis* Zone cannot be precisely correlated with the standard section, although it occurs within the time range of the "upper" Burlington Limestone in southeastern Iowa.

The faunal affinities of the Gilmore City Limestone and the middle Banff Formation suggest that marine communication must have existed between the mid-continent and the northern Cordilleran region at some time during the Early Mississippian. Comparison of the Banff brachiopod fauna with that of the correlative Lodgepole Formation in the Cordilleran region of the western United States is hampered by lack of information on macrofaunas from the Lodgepole. The Banff Formation can be approximately correlated with the Lodgepole Formation of Montana, but much of the Lodgepole brachiopod fauna is undescribed. Of the species described, about two dozen are identical to, or have close affinity with, Banff specimens.

The Banff brachiopod fauna is remarkably similar to Tournaisian faunas from the Kuznets Basin of southwest Siberia and comparable faunas from southeast Kazakhstan. This suggests that there was a relatively free faunal exchange between the north Cordilleran region and Siberia-Kazakhstania in Early Carboniferous time, although recent reassembly of Paleozoic continental plates (Scotese et al., 1979) does not show a direct link between these regions.

Sommaire

Cet ouvrage est la première importante monographie sur les brachiopodes de la formation de Banff, qui se situe dans l'ouest de l'Alberta. La faune décrite est diverse, et comprend des représentants des groupes suivants: orthidés ponctués, strophoménidés, orthotétidés, chonétidés, productidés, rhynchonéllidés, retziidés, athyrididés, spiriféridés non ponctués, spiriféridés et térébratulidés ponctués. Dans cet article, on décrit deux nouveaux genres, un nouveau sous-genre et vingt-quatre nouvelles espèces.

La formation de Banff comprend trois membres non désignés de façon officielle. Le membre "inférieur", autrement stérile, ne contient que des Conodontes et quelques rares brachiopodes articulés. Certains lits des membres "intermédiaire" et "supérieur" contiennent un nombre raisonnable de mégafossiles, en particulier dans le faciès "est", mais dans aucune coupe stratigraphique, on ne connaît de séquence fossilifère continue. Par conséquent, on doit établir une subdivision biostratigraphique de la formation de Banff à partir des mégafossiles présents, en étudiant les données sur leur distribution, obtenues dans plusieurs coupes stratigraphiques.

Macqueen et Bamber (1967) ont proposé une corrélation entre les formations de Pekisko et Shunda des Foothills de l'Alberta et de la région de Jasper (leur faciès "est"), et les formations du Mississippien inférieur de la vallée de la rivière Bow et des montagnes Rocheuses au sud (leur faciès "ouest"). On n'a pu déterminer avec certitude les relations chronologiques réelles entre ces faciès, mais on emploie quand même dans cette étude les termes de faciès "est" et "ouest". En général, il existe de nettes différences entre les faunes des faciès "est" et "ouest". Il n'existe de fortes similarités entre les faunes "est" et "ouest" que dans la plus basse des trois zones à brachiopodes énumérées ci-dessous.

Grâce à cette étude, on a établi trois zones biostratigraphiques d'après les données sur la distribution des fossiles recueillis dans 181 sites d'échantillonnage. Suivant un ordre stratigraphique ascendant, ce sont: la zone à *Calvustrigis rutherfordi*, la zone à *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis*, et la zone à *Avonia minnewankensis-Marginatia burlingtonensis*.

La zone à *Calvustrigis rutherfordi* est approximativement équivalente à la zone à *Platyrachella rutherfordi* proposée par Nelson (1961) pour le membre "intermédiaire" de la formation type de Banff et le membre "supérieur de Banff dans la région de Jasper. La faune est très abondante dans cette zone, et contient 73 des 87 espèces de la formation de Banff décrites dans cet article. De ce nombre, on trouve 71 espèces dans la faune du faciès "est" 28 dans la faune du faciès "ouest". Sur les 73 espèces que l'on trouve dans cette zone, 48 y sont confinées, ce qui fait de cette zone une bonne unité biostratigraphique. On ne rencontre que dans le membre "intermédiaire" les brachiopodes présents dans cette zone. Les lits fossilifères les plus bas du membre "supérieur" contiennent plusieurs espèces caractéristiques de la zone sus-jacente à *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis*.

La limite inférieure de la zone à *Stegacanthia* cf. *S. bowsheri* est délimitée par le plus bas niveau où l'on trouve trois espèces-clés. En outre, plusieurs autres espèces apparaissent pour la première fois dans la partie inférieure de la zone. Dans la région de la vallée de la rivière Bow, cette zone occupe approximativement les 200 pieds (60 m) inférieurs du membre "supérieur".

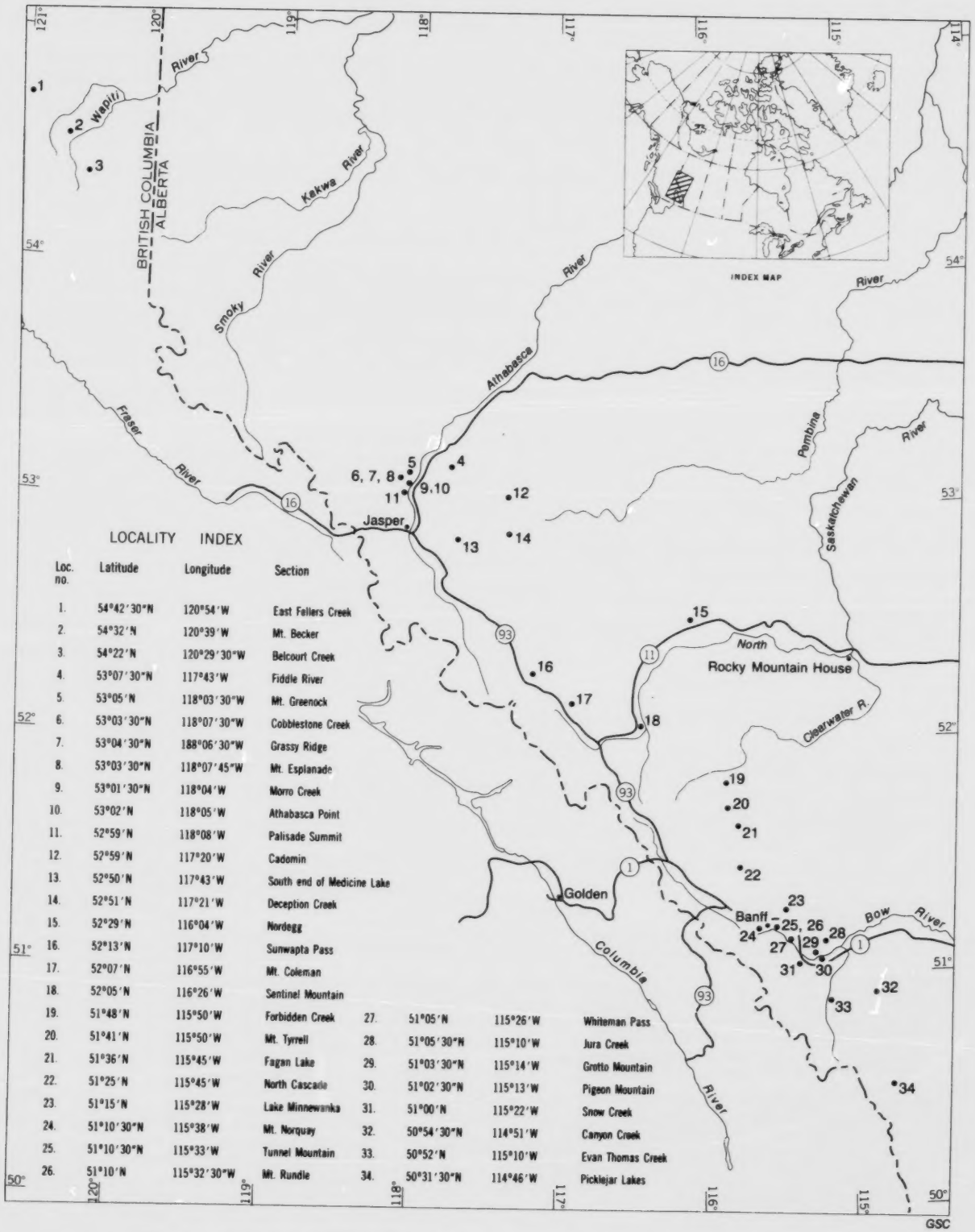
On a désigné la zone à *Avonia minnewankensis-Marginatia burlingtonensis* d'après deux productidés de caractère très distinctif et facilement reconnus. Cette zone occupe approximativement les 350 à 400 pieds (105 à 120 m) supérieurs du membre "supérieur" de la formation de Banff et les 100 à 150 pieds (30 à 45 m) inférieurs de la formation sus-jacente de Livingstone. Dans la région de la vallée de la rivière Bow, qui appartient au faciès ouest, les mégafossiles sont très rares au-dessus de cette zone dans la formation de Livingstone.

On a établi une corrélation entre la formation de Banff et la coupe type du système mississippien, dans la partie centrale du continent. En comparant la faune de Banff à la faune de brachiopodes du calcaire de Gilmore City, dans la partie nord-centrale de l'Iowa, on constate que 86 pour cent des genres de brachiopodes de cette dernière faune apparaissent aussi dans les assemblages à *Calvustrigis* de l'Alberta, et que la plupart des espèces sont identiques ou présentent d'étroites analogies. Les deux zones à brachiopodes de la partie "supérieure" de la formation de Banff, décrites dans ce rapport, appartiennent de toute évidence à l'Osagéen. Il est facile d'établir une corrélation entre la zone de l'intervalle à *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis*, et les formations de Meppen, Fern Glen, le Burlingtonien inférieur et la formation de Pierson dans le Missouri. Cette zone est entièrement absente dans le sud-est de l'Iowa.

In ne peut établir une corrélation précise entre les limites supérieures de la zone à brachiopodes du niveau le plus bas de la formation de Banff, c'est-à-dire de la zone à *Avonia minnewankensis-Marginatia burlingtonensis*, et la coupe type, bien que celle-ci se trouve dans l'intervalle temporel du calcaire "supérieur" de Burlington, dans le sud-est de l'Iowa.

Les affinités fauniques du calcaire de Gilmore City et de la partie intermédiaire de la formation de Banff, suggèrent que la mer a dû relier la partie centrale du continent et la région septentrionale de la Cordillère à un moment donné du Mississippien inférieur. En raison du manque d'information sur les macrofaunes de la formation de Lodgepole, il est difficile de comparer la faune de brachiopodes de Banff à celle de la formation correspondante de Lodgepole, située dans la région de la Cordillère, dans l'ouest des États-Unis. On peut approximativement établir une corrélation entre la formation de Banff et la formation de Lodgepole dans le Montana, mais il reste encore à décrire une grande partie de la faune de brachiopodes de Lodgepole. Parmi les espèces décrites, environ deux douzaines sont identiques aux spécimens recueillis à Banff, ou bien présentent une étroite affinité avec ceux-ci.

La faune de brachiopodes de Banff ressemble étonnamment aux faunes tournaisiennes du bassin du Kuznets situé dans le sud-ouest de la Sibérie, et à des faunes comparables du sud-est du Kazakhstan. Ceci suggère qu'il y a eu un échange faunique relativement facile entre la région septentrionale de la Cordillère et la région de la Sibérie et du Kazakhstan durant le Carbonifère inférieur, bien que l'assemblage des plaques continentales paléozoïques, schéma récemment proposé (Scotese et al., 1979), ne montre pas qu'il y ait eu un lien direct entre ces régions.



LOCALITY INDEX

Loc. no.	Latitude	Longitude	Section
1.	54°42′30″N	120°54′W	East Fellers Creek
2.	54°32′N	120°39′W	Mt. Becker
3.	54°22′N	120°29′30″W	Belcourt Creek
4.	53°07′30″N	117°43′W	Fiddle River
5.	53°05′N	118°03′30″W	Mt. Greenock
6.	53°03′30″N	118°07′30″W	Cobblestone Creek
7.	53°04′30″N	188°06′30″W	Grassy Ridge
8.	53°03′30″N	118°07′45″W	Mt. Esplanade
9.	53°01′30″N	118°04′W	Morro Creek
10.	53°02′N	118°05′W	Athabasca Point
11.	52°59′N	118°08′W	Palisade Summit
12.	52°59′N	117°20′W	Cadomin
13.	52°50′N	117°43′W	South end of Medicine Lake
14.	52°51′N	117°21′W	Deception Creek
15.	52°29′N	116°04′W	Nordegg
16.	52°13′N	117°10′W	Sunwapta Pass
17.	52°07′N	116°55′W	Mt. Coleman
18.	52°05′N	116°26′W	Sentinel Mountain
19.	51°48′N	115°50′W	Forbidden Creek
20.	51°41′N	115°50′W	Mt. Tyrrell
21.	51°36′N	115°45′W	Fagan Lake
22.	51°25′N	115°45′W	North Cascade
23.	51°15′N	115°28′W	Lake Minnewanka
24.	51°10′30″N	115°38′W	Mt. Norquay
25.	51°10′30″N	115°33′W	Tunnel Mountain
26.	51°10′N	115°32′30″W	Mt. Rundle
27.	51°05′N	115°26′W	Whiteman Pass
28.	51°05′30″N	115°10′W	Jura Creek
29.	51°03′30″N	115°14′W	Grotto Mountain
30.	51°02′30″N	115°13′W	Pigeon Mountain
31.	51°00′N	115°22′W	Snow Creek
32.	50°54′30″N	114°51′W	Canyon Creek
33.	50°52′N	115°10′W	Evan Thomas Creek
34.	50°31′30″N	114°46′W	Picklejar Lakes

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Figure 1. *Index map of principal Banff stratigraphic sections and collecting localities.*

INTRODUCTION

Brachiopods are the most common megafossils in the Banff Formation of Alberta, and are sporadically distributed in the middle and upper beds only, in all known areas of outcrop. Figure 1 indicates the geographic area studied in this report and the location of the main stratigraphic sections, from which most of the collections forming the basis of this report were recovered.

The brachiopod fauna described here consists of 87 species assigned to 53 genera and subgenera. The bulk of the fauna is endemic to the Cordilleran region of Canada and, to some extent, to the northern United States. In the Bow River valley region, the thick upper "member" contains several distinctive species common to the Mississippian standard section of the midcontinent, the presence of which allows relatively precise correlation and zonation. Some elements of the fauna are remarkably similar to forms described by Tolmachoff (1924, 1931) and Sarycheva et al. (1963) from the Kuznets Basin of southwestern Siberia, and by Bublichenko (1976) from southeastern Kazakhstan.

This report deals only with brachiopod faunas recovered from strata assigned by Geological Survey of Canada geologists to the Banff Formation. For comparative purposes, the author examined and identified most of the Geological Survey of Canada material from other formations of similar age in Western Canada. However, these faunas are not described in the present study because of their paucity, poor preservation, and the lack of good stratigraphic control. The brachiopod faunas of the other Lower Mississippian formations, underlying and overlying the Banff Formation, are of great importance in the zonation and correlation of the Mississippian strata of Alberta, especially in those units, such as the Pekisko and Shunda formations, where brachiopods constitute the most diverse megafaunas known.

The purpose of the present study is to describe all available elements of the Banff brachiopod fauna, to provide a well documented biostratigraphic framework based on brachiopods, and, by means of this framework, to make possible more precise megafossil correlations within the sedimentary basins of Western Canada and the western United States, and to correlate these with the standard section of the midcontinental Mississippian. The study is based upon all of the well documented collections of the Geological Survey of Canada, as well as collections made by the author at several critical localities.

Previous brachiopod studies

In 1913, Shimer briefly described, but did not illustrate, several spiriferid species from the Lake Minnewanka region, including several from the Banff Formation. This short, preliminary paper was followed in 1926 by the first major paleontological study of the Banff Formation faunas. In that work, Shimer described several new brachiopod species from the Banff Formation, including *Productus minnewankensis*, *Spirifer minnewankensis*, *Ambocoelia magna*, and *Cleiothyridina lata*. The beds from which the first two were described were assigned by Shimer to the Rundle Limestone. As presently interpreted, the lower several hundred feet of Shimer's formation are now assigned to the Banff Formation.

In the following year, Warren (1927) published a detailed description of the Banff Formation at its type locality, Mount Rundle, as well as fossil lists for the "middle" and "upper" members, and a description of *Spirifer cascadensis* Warren.

The faunas of the Banff Formation in the Jasper region were listed, and new taxa were described in Allan et al. (1932). In that paper, Warren described five of the most common and characteristic species in the Jasper fauna, viz. *Productus jasperensis*, *Camarotoechia allani*, *Spirifer albertensis*, *Spirifer rutherfordi*, and *Composita athabaskensis*.

Twenty years later, Brown (1952) gave a much more detailed account of the stratigraphy and paleontology of the Mount Greenock area, near Jasper. Brown's sections and well documented collections form the basis for part of the present study. Brown described a number of new species, including *Greenockia snaringensis*, *Spirifer greenockensis*, *S. esplanadensis*, *Rhynchotetra elongata usheri*, and several characteristic species from the lower Rundle Group as well.

The extensive faunal lists derived from the four papers above have been used as the basis for correlations with the midcontinental faunas of the upper Mississippi Valley. These faunal lists differ significantly from the list presented in this paper; a comparison of these lists is given in Table 1. Many of the equivalent identifications given in the right hand column of the table are based on this author's interpretation of the earlier authors' identifications, not on the actual specimens, although most of the Banff types and figured specimens were borrowed for study. Only Brown's collections were examined in their entirety.

In addition to these four early papers that contain descriptions of new species, several authors have redescribed or illustrated elements of the Banff Formation brachiopod fauna. Crickmay (1955), in connection with his restudy of Shimer's Lake Minnewanka stratigraphic section, reillustrated the type specimen of *Spirifer cascadensis* Warren and redescribed and reillustrated Warren's syntypes of *Spirifer albertensis*. Harker and Raasch (1958) illustrated two Banff spiriferids in their paper on megafaunal zones, and provided faunal lists, including many brachiopods, for four proposed zones occurring in the Banff Formation. Nelson (1961) illustrated a large part of the Banff brachiopod fauna in his treatment of the "Mississippian Faunas of Western Canada". His zonation of the Banff Formation by means of brachiopods and corals is similar to the scheme presented in this paper. Macqueen and Bamber (1968) and Bamber and Copeland (1970) illustrated, but did not describe, several characteristic Banff brachiopods in connection with stratigraphic and biochronological studies.

Faunal lists of Banff brachiopods, without illustrations or descriptions, can be found in papers by Beach (1943), Spreng (1953), and Douglas (1958).

Acknowledgments

This study was suggested and encouraged by E.W. Bamber of the Institute of Sedimentary and Petroleum Geology (Geological Survey of Canada), Calgary, Alberta. Completion of the paper would not have been possible without his enthusiastic support, for which I am very grateful. Joaquin Rodriguez deserves special thanks for his careful reviewing of the manuscript and numerous suggestions for improving it. R.W. Macqueen of the Institute

TABLE 1

Brachiopod species attributed to the Banff Formation

Species identified	Shimer (1926)	Warren (1927)	Warren (1932)	Brown (1952)	This paper
Ambocoelia magna Shimer	x				*Eomartiniopsis rostrata* (Girty)
Athyris lamellosa (Leveille)			x		?
Brachythyris burlingtonensis Weller				x	?
Brachythyris chouteauensis (Weller)			x	x	*Brachythyris chouteauensis* (Weller)
Brachythyris peculiaris (Shumard)			?		?
Camarotoechia allani Warren			x	x	*Hemiplethorhynchus allani* (Warren)
Camarotoechia elegantula Rowley	x				?
Camarotoechia chouteauensis Weller			cf.	x	*Macropotamorhynchus insolitus* n. sp.
Camarotoechia metallica (White)		x	x		?
Camarotoechia tuta (Miller)			cf.	x	*Macropotamorhynchus insolitus* n. sp.
Chonetes illinoisensis Worthen	x	x			*Rugosochonetes multicostus* (Winchell)
Chonetes logani Norwood and Pratten			x	cf.	*Subglobosochonetes norquayensis* n. sp.
Cleiothyridina glenparkensis Weller		x	?		?
Cleiothyridina hirsuta (Hall)		x	x		*Cleiothyridina tenuilineata* (Rowley)
Cleiothyridina lata Shimer	x	x	x	x	*Cleiothyridina lata* Shimer
Cleiothyridina obmaxima (McChesney)			x		*Cleiothyridina lata* Shimer
Cleiothyridina parvirostris (Meek and Worthen)	x				?
Composita athabaskensis Warren			x	x	*Composita athabaskensis* Warren
Composita humilis (Girty)		x	x	x	*Composita humilis* (Girty)
Composita immatura (Girty)				x	*Composita immatura* (Girty)
Composita madisonensis (Girty)			x		Athyridid gen. et sp. indet.
Composita madisonensis pusilla (Girty)				x	*Composita prolixa* n. sp.
Cyrtina acutirostris Shumard				x	?
Dictyoclostus arcuatus (Hall)				x	*Spinocarinifera arcuata* (Hall)
Dictyoclostus gallatinensis (Girty)				x	*Tomiproductus gallatinensis* (Girty)
Dictyoclostus jasperensis (Warren)				x	*Setigerites jasperensis* (Warren)
Dielasma chouteauensis Weller	x	x		cf.	*Beecheria chouteauensis* (Weller)
Dielasma utah (Hall and Whitfield)		x			?
Enteletes hemiplicata (Hall)	cf.				?
Eumetria osagensis (Swallow)				x	*Eumetria osagensis* (Swallow)
Eumetria verneuiliana (Hall)		x	x		*Eumetria osagensis* (Swallow)
Greenockia snaringensis Brown				x	*Hemiplethorhynchus snaringensis* (Brown)
Hustedia circularis (Miller)	x				*Hustedia circularis* (Miller)
Leiorhynchus haguei Girty		x			?
Leptaena analoga (Phillips)	x	x	x	x	*Leptagonia missouriensis* Carter
Linoproductus ovatus (Hall)				x	*Ovatia prolata* n. sp.
Martinia rostrata Girty			x	cf.	*Eomartiniopsis rostrata* (Girty)
Platyrachella rutherfordi (Warren)				x	*Calvustrigis rutherfordi* (Warren)
Productella concentrica (Hall)	?		x		*Avonia? beckerensis* n. sp.
Productella pyxidata (Hall)		x		cf.	*Rugauris robusta* n. sp.
Productus arcuatus Hall		x			*Spinocarinifera arcuata* (Hall)
Productus blairi Miller	x	x			*Stegacanthia* cf. *S. bowsheri* Muir-Wood and Cooper
Productus burlingtonensis Hall	x	x			*Marginatia burlingtonensis* (Hall)

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of Sedimentary and Petroleum Geology (Geological Survey of Canada), generously encouraged the use of his extensive field collections, many of which form the basis for a large part of the new biostratigraphic data presented here. T.E. Bolton of the Geological Survey of Canada, Ottawa, Professor C.R. Stelck of the University of Alberta, Edmonton, and R.E. Grant of the National Museum of Natural History, Washington, D.C., loaned types and referred specimens, for which I thank them.

S. Baxter kindly allowed me to examine the conodont manuscript that he was preparing with P. von Bitter (1984), which was still in press when this report was being written. P. Olughan, M. Townsend, and A. Kollar provided assistance with the photography and technical assistance. A. Kollar also typed much of the original manuscript. For all of this valued help I am most grateful.

STRATIGRAPHY

The name "Banff" was first used by R.G. McConnell (1887) for the thick Devonian through Triassic succession of the Bow River valley region. Kindle (1924) restricted the usage of the term to McConnell's "Lower Banff shale" and "Lower Banff limestone", and renamed McConnell's "Upper Banff limestone" the Rundle limestone (now the Rundle Group). Shimer (1926) further restricted the term by removing the "Lower Banff limestone", which is of Devonian Age (Palliser Formation). Some years later, Warren (1937) delimited the Exshaw Formation, a black shale formerly included with the lower shaly "member" of the Banff.

As presently defined, the Banff Formation is a shallowing-upward succession of calcareous or dolomitic

TABLE 1 (cont.)

Brachiopod species attributed to the Banff Formation

Species identified	Shimer (1926)	Warren (1927)	Warren (1932)	Brown (1952)	This paper
Productus fernglenensis Weller	X	X			*Marginatia fernglenensis* (Weller)
Productus gallatinensis Girty	X	X	X		*Tomiproductus gallatinensis* (Girty)
Productus jasperensis Warren			X		*Setigerites jasperensis* (Warren)
Productus minnewankensis Shimer	X				*Avonia minnewankensis* (Shimer)
Productus ovatus Hall	X	X	X		*Ovatia prolata* n. sp.
Productus sedaliensis Weller			cf.		*Piloricilla desmetensis* n. sp.
Pseudosyrinx gigas Weller	X				*Verkhotomia jucunda* n. sp.
Pseudosyrinx sp.		X			*Verkhotomia jucunda* n. sp.
Punctospirifer solidirostris (White)				X	*Punctospirifer solidirostris* (White)
Reticularia cooperensis (Swallow)		X	X		*Kitakamithyris cooperensis* (Swallow)
Reticularia pseudolineata (Hall)	X		X		*Torynifer pseudolineatus* (Hall)
Reticularia tenuispinata (Herrick)		X			?
Rhipidomella missouriensis (Swallow)				X	*Rhipidomella* sp.
Rhipidomella pulchella Herrick		X			*Rhipidomella* sp.
Rhynchopora pustulosa (White)		X			?
Rhynchotetra elongata usheri Brown				X	*Axiodeaneia usheri* (Brown)
Schellwienella inequalis (Hall)	X	X		X	*Schellwienella chouteauensis* Weller
Schellwienella planumbona Weller		X			*Schellwienella* cf. *S. bushbergensis* Brown
Schizophoria chouteauensis Weller	X				*Schizophoria* cf. *S. postriatula* Weller
Schizophoria poststriatula Weller		X			*Schizophoria* cf. *S. postriatula* Weller
Schizophoria sp.				X	?
Schuchertella chemungensis (Conrad)			X		?
Schuchertella lens (White)			X		?
Shumardella missouriensis (Shumard)		?			*Shumardella beckerensis* n. sp.
Spirifer albapinensis Hall and Whitfield	X	X			*Prospira albapinensis* Hall and Whitfield
Spirifer albertensis Warren			X	X	*Podtsheremia albertensis* (Warren)
Spirifer cascadensis Warren		X		cf.	*Spirifer cascadensis* Warren
Spirifer centronatus Winchell	X	X	X		?
Spirifer centronatus minnewankensis Shimer	X			X	*Unispirifer minnewankensis* (Shimer)
Spirifer esplanadensis Brown				X	*Spirifer esplanadensis* Brown
Spirifer greenockensis Brown				X	*Unispirifer greenockensis* (Brown)
Spirifer grimesi Hall		X			*Spirifer mountraensis* n. sp.
Spirifer marionensis Shumard		cf.		X	?
Spirifer rutherfordi Warren			X		*Calvustrigis rutherfordi* (Warren)
Spirifer striatiformis Meek	X	cf.	X		?
Spirifer tenuimarginatus Hall	X				*Spirifer esplanadensis* Brown
Spiriferella minnewankensis Shimer	X	cf.			?
Spiriferina cristata (Schlotheim)		?			?
Spiriferina solidirostris White			X		*Punctospirifer solidirostris* (White)
Spiriferina subtexta White			X		*Punctospirifer subtexta* (White)
Syringothyris hannibalensis (Swallow)			?	X	*Syringothyris* cf. *S. hannibalensis* (Swallow)
Squamularia depressiplicata Shimer	X				?
Torynifer pseudolineatus jasperensis Brown				X	*Torynifer eufastigium* n. sp.

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shale and skeletal lime wackestone and packstone, with subordinate lime grainstone. Shale predominates in the lower part of the formation, but decreases in abundance toward the upper part, where limestone is the main constituent. The formation is bounded at the base by the shale and siltstone of the Exshaw Formation or the carbonates of the Palliser Formation, and at the top by the resistant, massive, light grey weathering, coarse grained, echinoderm-bryozoan lime grainstone or dolomitized limestone of the Rundle Group.

Although McConnell first used the term "Banff" in a stratigraphic sense, Kindle (1924) is commonly considered to be the author of the Banff Formation. The stratigraphic section on the north side of Mount Rundle was first described by Warren (1927) and this steep slope is commonly considered to be the type section, although Kindle did not designate which part of Mount Rundle he considered to be the actual type section. At Mount Rundle, Warren delimited three so-called members, which he informally designated lower, middle, and upper. Subsequent authors have continued to use a two- or three-part subdivision for the Banff, but only on an informal basis.

The thickness of the Banff Formation, as defined above, varies greatly. It is 1200 feet (365 m) or more thick in the Bow River valley region and about 600 feet (185 m) thick in the Jasper region. In the Front Ranges near Banff, the shelf-slope deposits of the Banff Formation are succeeded by the Livingstone Formation, a thick, massive, grain-supported limestone representing open marine, high energy depositional conditions. In the Jasper region and the central foothills east of Banff, the Lower Rundle Group is represented by a peritidal succession consisting of the Pekisko, Shunda, and Turner Valley formations (Fig. 4). The Pekisko, which

overlies the Banff Formation, consists of coarse grained, light grey, echinoderm-bryozoan lime grainstone. It is succeeded by the dark grey, restricted, shallow marine, algal and foraminiferal micritic limestone of the Shunda Formation, which contains little chert and detrital material, but abundant pelletoid grains, fenestral fabric, and local development of solution breccia. The overlying Turner Valley Formation is a massive echinoderm lime grainstone and packstone and is commonly dolomitic. Some authors, notably Moore (1958), Nelson and Rudy (1959), Middleton (1963), and Green (1962), consider that the Pekisko and much of the Shunda can be correlated with the upper Banff "member" at Mount Rundle, thus accounting for much of the great discrepancy in thickness. However, the correlation between the upper Banff strata and those of the Pekisko and Shunda formations is not based on very convincing paleontological data. Except for brachiopods and corals, the Pekisko and Shunda megafaunas are poor, and they have very few brachiopod and coral species in common with Bow River valley faunas. Achieving satisfactory correlations with that succession is therefore difficult.

More recently, Macqueen and Bamber (1967) presented the view that the Pekisko and Shunda formations are lateral equivalents of the lower and middle Livingstone Formation. Their correlation was based on both lithological and paleontological evidence, mainly from the eastern Front Ranges and Foothills. The faunal evidence presented by these authors for more westerly sections, however, is insufficient for precise correlation with the type area of the Banff Formation (Macqueen and Bamber, 1967, p. 10).

The correlation of the Pekisko and Shunda formations of the Alberta Foothills and Jasper region (the "eastern" facies of Macqueen and Bamber, 1967) with the Lower Mississippian formations of the Bow River valley and the Rocky Mountains to the south (Macqueen and Bamber's "western" facies) remains uncertain. Only well documented paleontological evidence based on several fossil groups can establish the true chronological relationships between these two successions.

STRATIGRAPHIC PALEONTOLOGY

In general, the Banff Formation is not very fossiliferous. The so-called "lower" member is virtually barren except for conodonts and rare, inarticulate brachiopods. In the Jasper area, Green (1963, p. 69) reported the presence of conodonts in a thin, arkosic sandstone overlying the Devonian Palliser Formation, and Baxter (1972) reported conodonts from the entire Banff sequence in the Bow River valley.

Some beds in the "middle" and "upper" members of the Banff contain reasonably numerous megafossils, particularly in the "eastern" facies, but continuously fossiliferous sequences are not known at any single stratigraphic section for any group of megafossils. Where the Banff is fossiliferous, brachiopods usually make up the bulk of the megafauna both in numbers and in diversity. Any biostratigraphic subdivision of the Banff Formation based on megafossils is by necessity assembled from the distribution data from several stratigraphic sections.

Previous megafossil studies

The first effort to delineate biostratigraphic units in the Banff Formation was made by R.A.C. Brown (1952) (see Table 2). He recognized two "faunules" in the Banff and one in the Lower Rundle Group. Brown's lowest subdivision, the *Spirifer* cf. *cascadensis* Faunule, is not recognized in this report. All of Brown's collections attributed by him to this faunule were examined and reidentified for the present study. This writer can detect no species occurrences in these collections that characterize the *Spirifer* cf. *cascadensis* Faunule alone. In fact, all identifiable specimens are assignable to species that range well up into the upper Banff of the "eastern" facies. Brown's uppermost Banff subdivision, the *Spirifer albertensis* Faunule, is essentially equivalent to the *Calvustrigis rutherfordi* Zone used in this report.

In 1958, Harker and Raasch presented another zonation scheme for the Banff and other Mississippian formations based on megafossils. Their *Spirifer marionensis* Zone is more or less equated with Brown's *Spirifer* cf. *cascadensis* Faunule discussed above. None of the species identified by Harker and Raasch from their *Spirifer marionensis* Zone is recognized in this paper. The overlying *Spirifer missouriensis* Zone (identified here as *Podtsheremia*? *albertensis*) equals Brown's *Spirifer albertensis* Faunule. In addition, Harker and Raasch delineated two more megafossil zones in the Banff at Mount Rundle. The lowest of these, the *Camarotoechia cobblestonensis* Zone, according to Harker and Raasch (1958, p. 226), appears to be present in Warren's "Middle Banff". Their list of fossils contains few species described in this report collected from the same general stratigraphic interval. In fact, their list contains species variously restricted to each of the three Banff zones delimited in this paper. The uppermost Banff zone of Harker and Raasch, the *Spirifer rowleyi* Zone, was "provisionally employed for the fauna occurring in Warren's (1927) 'Upper Beds of the Banff Formation' " (Harker and Raasch, 1958, p. 224). The beds and fauna referred to by Warren, and Harker and Raasch occur within the upper two zones of this paper.

Nelson (1960) devised a zonation for the Banff based on corals, emending it later (Nelson, 1961) to include brachiopods. The lowest zone employed by Nelson, the *Platyrachella rutherfordi* Zone, is an assemblage zone based on the megafauna of the "middle" Banff fauna at Mount Rundle and the "upper" Banff fauna in the Jasper region. This assemblage zone is used in the present study, where it is referred to as the *Calvustrigis rutherfordi* Zone. The two uppermost Banff zones proposed by Nelson, the *Lithostrotionella micra* and *Lithostrotion mutabile* zones appear to be essentially equivalent to the upper two zones used in this report, the *Stegacanthia* cf. *S. bowsheri-Marginatia ferndalenensis* and *Avonia minnewankensis-Marginatia burlingtonensis* zones. The latter zones are employed here because corals are not used in this study and because Nelson did not define zonal boundaries or list comprehensive megafaunas.

The zonation systems proposed by the previous authors were combined and emended by Green (1962) in order to clarify their interrelationships and establish a more consistent zonal classification. Green retained the *Spirifer marionensis* Zone of Harker and Raasch, but with reservations, due to the uncertainty of the true identity of the zonal name-giver, a Late Devonian species. He also retained their *Spirifer missouriensis* Zone in preference to Nelson's *Platyrachella rutherfordi* Zone, noting that the two

TABLE 2

Generalized comparison of zonal schemes
proposed for the Banff Formation of western Alberta

STRATIGRAPHIC UNITS IN THE BOW VALLEY (WESTERN FACIES)		BOTH FACIES	WESTERN FACIES	BOTH FACIES	WESTERN FACIES	EASTERN FACIES	BOTH FACIES	BOTH FACIES	BOTH FACIES
		THIS PAPER	NELSON (1961)	GREEN (1962)	HARKER AND RAASCH (1958)	BROWN (1952)	SANDO AND BAMBER (1985)	MAMET (1976)	BAXTER AND VON BITTER (1984)
LIVINGSTONE FORMATION (lower part)		Not zoned	*Spirifer banffensis* Zone	*Spirifer rundlensis* Zone	*Spirifer forbesi* Zone	Not zoned		Zone 8	*Eotaphrus-Bactrognathus* Zone
BANFF FORMATION	"upper" member	*Avonia minnewankensis-Marginatia burlingtonensis* Zone	*Lithostrotion mutabile* Zone	*Spirifer forbesi* Zone	*Spirifer rowleyi* Zone	*Composita esplanadensis* or *Spirifer minnewankensis* Faunule	Coral Zone 2	Zone 7	*Bactrognathus-Polygnathus communis* Zone
		Stegacanthia cf. *S. bowsheri-Marginatia ferniglenensis* Zone	*Lithostrotionella micra* Zone		*Camarotoechia cobblestonensis* Zone				*Gnathodus semiglaber-Polygnathus communis carinus* Zone
	"middle" member	*Calvustrigis rutherfordi* Zone	*Platyrachella rutherfordi* Zone	*Spirifer missouriensis* Zone	*Spirifer missouriensis* Zone	*Spirifer albertensis* Faunule			*Siphonodella cooperi hassi-Gnathodus punctatus* Zone
					Spirifer marionensis Zone	*Spirifer* cf. *S. cascadensis* Faunule	Not zoned		
	"lower" member	Not zoned	Unnamed zone	? *Spirifer marionensis* Zone	*Angustidontus seriatus* Zone	Not zoned		Pre-7	*Siphonodella-Pseudopolygnathus* Zone
									Siphonodella sandbergi-Siphonodella duplicata Zone

GSC

are, in general, coeval. Green then redefined the *Spirifer forbesi* Zone of Harker and Raasch to encompass all of the faunas of the "upper" Banff at Mount Rundle, including the *Camarotoechia cobblestonensis*, *Spirifer rowleyi*, and *Spirifer forbesi* zones of Harker and Raasch, and the *Lithostrotionella micra* and *Lithostrotion mutabile* zones of Nelson. *Unispirifer minnewankensis* (Shimer), called *Spirifer forbesi* by many earlier authors, does indeed range throughout the "upper" Banff and lower Livingstone formations, as suggested by Green. However, using total range to define a zone offers relatively poor biostratigraphic resolution.

Sando and Bamber (1985) have recently proposed a coral zonation of the Mississippian of western North America that includes the coral faunas of part of the Banff Formation and the Rundle Group of Alberta. In this work, the lower part of the Banff is not zoned because of the scarcity of diagnostic coral species. The upper part of the Banff is assigned to their Coral Zone 2 in both facies.

Microfaunal studies

Loranger (1958) recognized three, broad, microfaunal zones based on ostracodes for the Mississippian of Western Canada. One of these, the *Richterina* Zone, characterizes the Banff Formation. Loranger's zones were apparently not intended to be used for precise biostratigraphic correlation, but were used by her to solve regional, structural, and stratigraphic problems. Green (1963) described a large Banff ostracode fauna with many new species, but did not present a zonation scheme.

McKay and Green (1963) recognized several foraminiferal zones in the Mississippian of Alberta, including one from the Banff Formation near Jasper. The foraminifers found there were assigned to the long ranging *Endothyra tumula* Range Zone.

Mamet and Mason (1968), Petryk, Mamet, and Macqueen (1970), and Mamet (1976) did not recognize the substantial east-west diachronism, which has been attributed to the upper Banff beds in several previous studies and in this paper. They assigned the uppermost Banff beds of both facies to Zone 7 of Mamet and Skipp (1971), which was correlated with the type Burlington Limestone of southeastern Iowa. According to Baxter and Brenckle (1982, p. 141) calcareous microfossils are extremely rare in the Meppen through Burlington sequence of the Mississippi Valley region. Their studies of extensive Keokuk and younger calcareous microbiotas suggest that the Mamet and Skipp zones should be adjusted downward for most of the Kinderhookian and Valmeyeran section in the Mississippi

Valley. In north-central Iowa, Baxter and Brenckle discovered a rich Cordilleran foraminiferal fauna in the type Gilmore City Limestone, which can be readily assigned to Zone 7 of Mamet and Skipp. The type Gilmore City Limestone contains late Kinderhookian megafossils (Laudon, 1933; Carter, 1972) and siphonodellid conodonts (Anderson, 1973). Petryk, Mamet, and Macqueen (1970, p. 99, Fig. 6) placed the "*Platyrachella*" *rutherfordi* fauna in Zone 7, but assigned this zone to the Osagean.

Conodonts have been reported from the Upper Devonian and Lower Mississippian of Western Canada by several authors, including Cooper and Sloss (1943), Raasch (1956), Pamenter (1956, 1965), Macqueen and Sandberg (1970), Copeland (1960), Müller (1962), and Green (1962, 1963), usually from the Exshaw Formation just below the Banff. In an unpublished doctoral thesis, Baxter (1972) described a large number of conodont taxa from the entire Mississippian succession in southwestern Alberta and southeastern British Columbia and erected an extensive zonation scheme for the system, including five zones and several subzones for the Banff Formation, these last zones were slightly emended in Baxter and von Bitter (1984). Although Baxter did not collect at Mount Rundle proper, his extensive examination of several Bow Valley measured sections affords a reasonable comparison with the megafossil zones presented here. Baxter and von Bitter's *Pseudopolygnathus-Siphonodella* Zone appears to extend through most of the "lower" Banff and part of the "middle" Banff. The fossiliferous "middle" Banff of the Bow River valley, and the "upper" member in the Jasper region bearing the more common Banff brachiopods are represented by the *Siphonodella cooperi hassi-Gnathodus punctatus* Zone, and are essentially equivalent to the *Calvustrigis rutherfordi* Zone of this paper. The *Gnathodus semiglaber-Polygnathus communis carina* and *Bactrognathus-Polygnathus communis* zones appear to represent the "upper" Banff in the Bow River valley, and thus roughly compare with much of the upper two brachiopod zones in this paper, the *Stegacanthia* cf. *S. bowsheri-Marginatia ferglenensis* and *Avonia minnewankensis-Marginatia burlingtonensis* zones. The latter brachiopod zone extends into the lower Livingstone Formation and apparently overlaps with the lower *Bactrognathus-Eotaphrus* Conodont Zone in the Bow River valley. Without collecting both micro- and megafossils simultaneously, it is not possible to establish the exact relationships of the zonal boundaries for brachiopods and conodonts.

Sandberg et al. (1978) have recently proposed a standard global *Siphonodella* zonation for the lower and middle Tournaisian. Sandberg (1979) elaborated on this zonal scheme in his application of it to the Great Basin and Rocky Mountain regions of the United States. Lane et al. (1980) proposed a preliminary global post-*Siphonodella* zonation for the remainder of the Tournaisian and early Viséan. These zonal schemes postdate the work of Baxter (1972) and Baxter and von Bitter (1984), and exact comparisons between them are not readily apparent.

Brachiopod zones

The Banff Formation at its type section on Mount Rundle, and in the nearby Bow River valley region of the western facies, can be divided into three brachiopod zones. These zones are based on stratigraphic data gained from over 6900 well documented brachiopod specimens. The lowest of these, the *Calvustrigis rutherfordi* Zone, is an assemblage zone with an indefinite or unfixed lower boundary due to a virtual absence of megafossils in the lower several hundred feet of the Banff Formation throughout western Alberta. The upper two zones, the *Stegacanthia* cf. *S. bowsheri-Marginatia ferglenensis* Zone and the *Avonia minnewankensis-Marginatia burlingtonensis* Zone, are range zones based on the lowest and highest occurrences of several brachiopod species. Figure 2 shows the stratigraphic ranges of the biostratigraphically most useful Banff Formation brachiopod species in the Bow River valley region. Detailed distribution data for brachiopod species are given in the range charts in Appendix 2 (Figures 30-46).

The subdivision of the Banff outcrop area into eastern and western facies (Macqueen and Bamber, 1967) is used throughout the following pages in the same sense as that established by these authors.

Calvustrigis rutherfordi Zone

The *Calvustrigis rutherfordi* Zone (or *Platyrachella rutherfordi* Zone) was proposed by Nelson (1961) for the "middle" member of the type Banff Formation and the "upper" member of the Banff in the Jasper region. The fauna of this zone is very large, comprising 73 of the 87 Banff species described here; of this number, 71 species are found in the eastern facies fauna, whereas the western facies is much less diverse, consisting of only 28 species. Of the 73 total species found in this zone, 48 are restricted to it, of which 31 are found only in the eastern facies. Ten species range into the overlying *Stegacanthia* cf. *S. bowsheri-Marginatia ferglenensis* Zone in the western facies, and 14 species range into the highest brachiopod zone of the Banff, the *Avonia minnewankensis-Marginatia burlingtonensis* Zone. The upper range of one species cannot be determined or estimated. Figure 3 shows the stratigraphic distribution of the most common species from this zone in the Jasper region.

Not all of the "middle" member (eastern facies) is fossiliferous. To the author's knowledge, the *Calvustrigis rutherfordi* fauna never extends to the basal beds of this lithological interval. However, the lowest fossiliferous beds usually do occur somewhere in the lower quarter of this so-called member or some 300 to 500 feet (90-150 m) above the base of the formation, depending on facies and local variation in unit thickness. It has been determined from the data assembled for this report that many, if not most, of the species that typify this zone first occur within a thin interval comprising a few tens of feet in the eastern facies. This implies that the *Calvustrigis* assemblage first appears with very high diversity. In the eastern facies, where good data are readily available, it can be seen from Figure 3 that most of the common members of this assemblage range throughout. It is suspected that much of the stratigraphic range variation that does appear is due to insufficient sampling or variation in collecting and preparation techniques. For this reason, Brown's (1952, p. 59) *Spirifer* cf. *cascadensis* Faunule is not accepted in this report as a recognizable entity.

This zone extends upward at least to the top beds of the resistant limestone unit called the "middle" member in the Bow River valley region. The lower few feet of the "upper" member in this area are barren of megafossils. For convenience, and because of lack of evidence to the contrary, the *Calvustrigis rutherfordi* Zone is restricted to the "middle" member for this report. The lowest fossiliferous beds in the "upper" member contain several species that mark the next younger zone.

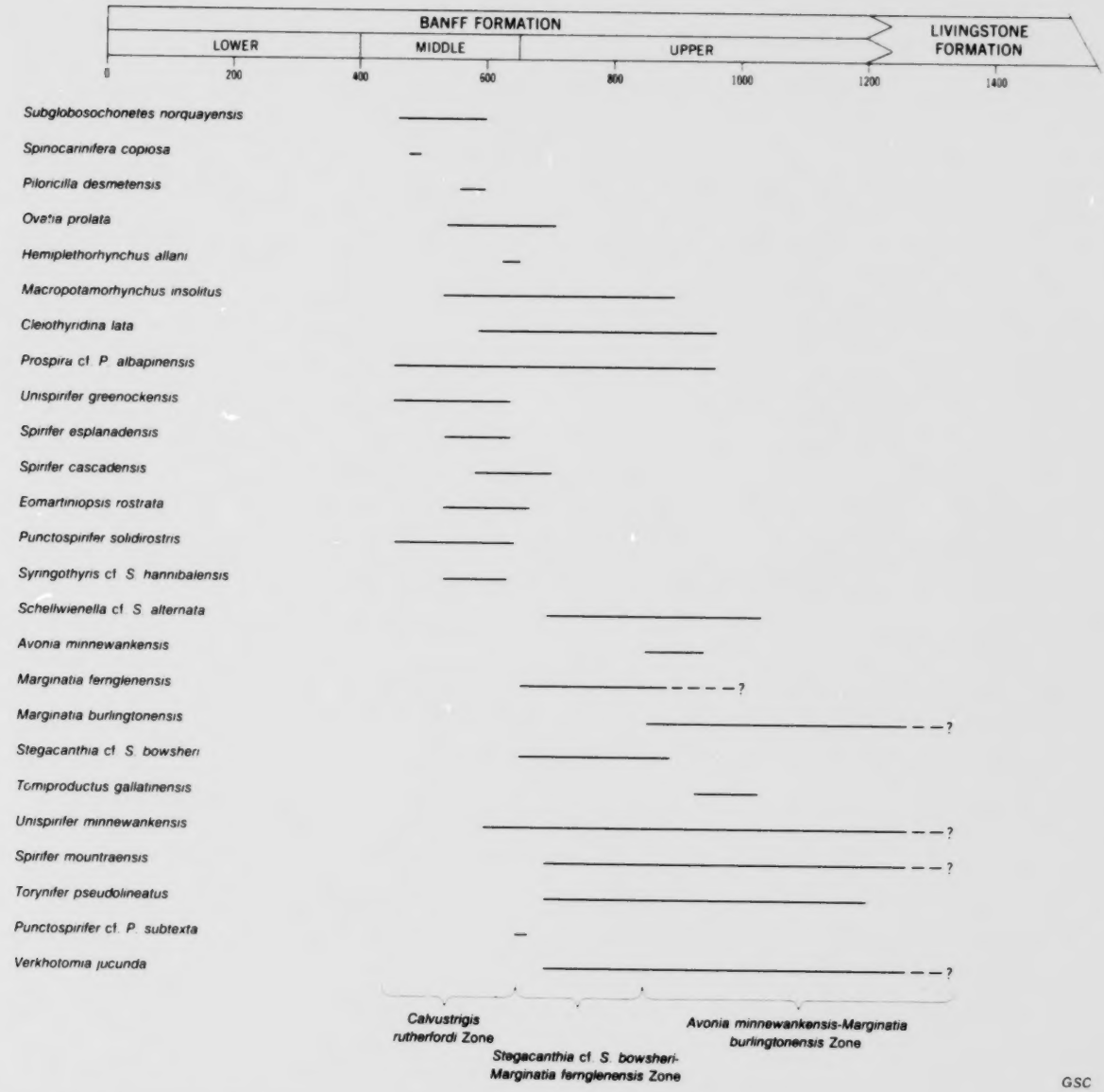

Figure 2. *Composite stratigraphic occurrences of the biostratigraphically useful brachiopod species of the Banff Formation in the Bow Valley region.*

Stegacanthia *cf.* S. bowsheri-Marginatia ferglenensis *Zone*

The lower boundary of the *Stegacanthia* cf. *S. bowsheri-Marginatia ferglenensis* Zone is delimited by the lowest occurrence of the following species: *Stegacanthia* cf. *S. bowsheri* Muir-Wood and Cooper, *Marginatia ferglenensis* (Weller), and *Punctospirifer* cf. *subtexta* (White). In addition, the following species first appear in the lower part of this zone: *Schellwienella* cf. *S. alternata* Weller, *Spirifer mountraensis* n. sp., *Torynifer pseudolineatus* (Hall), and *Verkhotomia jucunda* n. sp. Long-ranging species that have been carried over from the underlying zone include *Macropotamorhynchus insolitum* n. sp., *Cleiothyridina lata* Shimer, *Prospira* cf. *P. albapinensis* (Hall and Whitfield), and *Unispirifer minnewankensis* (Shimer). The highest occurrences of several distinctive species are in the lower part of this zone, namely *Ovatia prolata* n. sp., *Spirifer cascadensis* Warren, *Eomartiniopsis rostrata* (Girty), and *Punctospirifer* cf. *subtexta* (White).

In the Bow River valley region this zone occupies approximately the lower 200 feet (60 m) of the "upper" member, although this footage is very tentative for the sections that are difficult to measure. The most common faunal element in this zone is the long-ranging *Unispirifer minnewankensis* (Shimer). The large spiriferids *Spirifer mountraensis* n. sp. and *Verkhotomia jucunda* n. sp. are very numerous in the upper part of this zone.

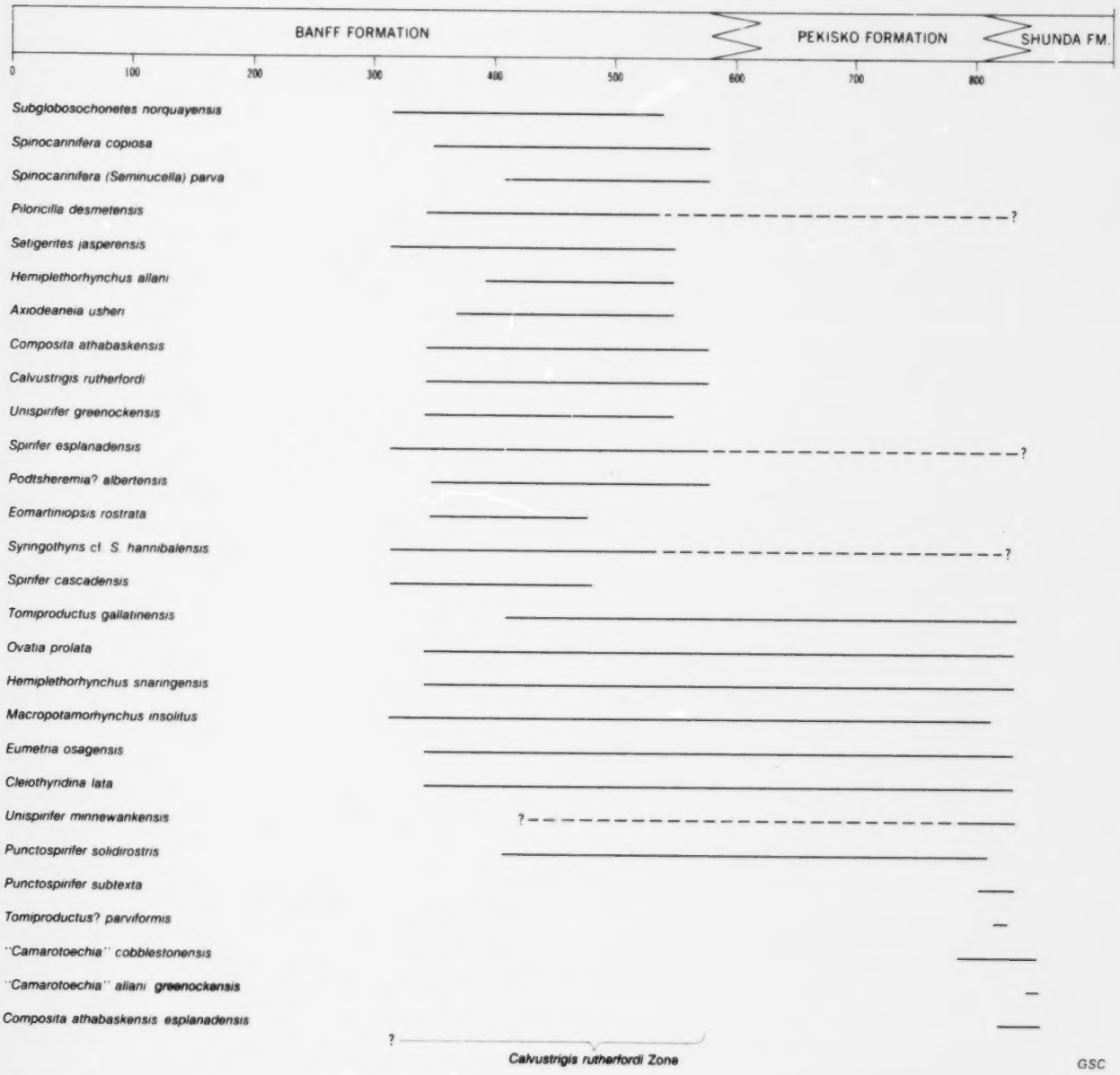

Figure 3. *Stratigraphic ranges of the biostratigraphically useful brachiopod species of the Banff Formation and lower Rundle Group in the Jasper, Alberta, region.*

The *Lithostrotionella micra* Zone described by Nelson (1961, p. 21), based on an assemblage of corals and brachiopods, is probably an approximate equivalent of this brachiopod unit (Table 2). Its lower boundary is the base of the "upper" member of the type section of the Banff, but its upper limits are vaguely defined.

Baxter's (1972) conodont zonation would probably place the base of the *Gnathodus semiglaber-Polygnathus communis carina* Zone near the base of the "upper" member in the western facies. Thus, the base of the *Gnathodus semiglaber-Polygnathus communis carina* Zone is approximately equivalent to the base of the *Stegacanthia* cf. *S. bowsheri-Marginatia ferniglenensis* Zone. The top of the brachiopod zone would occur within the *Bactrognathus-Polygnathus communis* Zone of Baxter and von Bitter (1984).

Avonia minnewankensis-Marginatia burlingtonensis Zone

The *Avonia minnewankensis-Marginatia burlingtonensis* Zone is named after two very distinctive and easily recognized productid species. *Avonia minnewankensis* (Shimer) is a small, finely ribbed species, probably identical to *Avonia linospinosa* Sutton from the Burlington Limestone of the midcontinent. Representatives of *Marginatia burlingtonensis* from the Banff Formation also appear to be indistinguishable from authentic Burlington Limestone specimens.

In the Bow Valley region, this zone occupies approximately the upper 350 to 400 feet (105-120 m) of the "upper" member of the Banff Formation and the lower 100 to

150 feet (30-45 m) of the Livingstone Formation. The lower boundary is defined by the first appearance of the zonal name-givers. *Avonia minnewankensis* occurs only in the lower part of the zone. In the western facies, *Tomiproductus gallatinensis* (Girty) also occurs entirely within this zone. *Schellwienella* cf. *S. alternata* Weller, *Marginatia ferrglenensis* (Weller), and *Stegacanthia* cf. *S. bowsheri* Muir-Wood and Cooper disappear approximately in the lower half of the zone. The upper limit of the zone is delineated by the last occurrences of *Marginatia burlingtonensis, Unispirifer minnewankensis, Spirifer mountraensis, Torynifer pseudolineatus,* and *Verkhotomia jucunda.* It should be mentioned that in the Bow River valley region of the western facies, megafossils are very rare above this zone in the Livingstone Formation. Considering the virtual absence of succeeding megafaunas, the upper boundary of this zone must be viewed as tentative. Nelson (1961, p. 22) proposed a *Spirifer banffensis* Zone for about 500 feet (150 m) of Livingstone Formation beds above his *Lithostrotion mutabile* Zone. He based this zone on six brachiopod species and described the fauna as "meagre". The author has not studied Livingstone Formation brachiopod faunas in detail. The appearance of the *Spirifer banffensis* fauna would provide another means of determining the upper limits of the *Avonia minnewankensis-Marginatia burlingtonensis* Zone.

The *Lithostrotion mutabile* Zone of Nelson (1961, p. 22) seems to span about the same general interval of strata in the Bow River valley region as the *Avonia minnewankensis-Marginatia burlingtonensis* Zone (Table 2), although Nelson did not define his zone on the basis of species ranges.

It is difficult to compare this zone based on brachiopods with the zonal sequence based on conodonts of Baxter and von Bitter (1984). Examination of their Figure 2 suggests that the *Avonia minnewankensis-Marginatia burlingtonensis* Zone in the Bow River valley region is probably equivalent to the upper part of the *Bactrognathus-Polygnathus communis* Zone and possibly the basal part of the *Bactrognathus-Eotaphrus* Zone.

Faunal composition

Information concerning the relative abundance, habitats, faunal associations, and geographic distribution of the Banff brachiopod fauna is worthy of brief review, as is their highly variable stratigraphic distribution, which will be discussed in subsequent pages.

Inarticulates

These have been recovered at only two localities. A single specimen of *Lingula* was found by Harker in the basal Banff at Mount Norquay, and Mountjoy collected several specimens of *Orbiculoidea* and one of *Lingula* in association with numerous *Crurithyris* specimens from the Banff in the Miette area, Jasper Park. It appears that inarticulates are extremely rare in the Banff Formation.

Punctate orthids

This group is also poorly represented in the Banff Formation. Small to medium-sized specimens of *Rhipidomella* occur rarely in the *Calvustrigis rutherfordi* Zone in both eastern and western facies and slightly more commonly in the "upper" member of the western facies. *Schizophoria* cf. *S. poststriatula* Weller shares a similar sparse distribution. *Rhipidomella* was most commonly found in association with various spiriferaceans in the eastern facies. In the "upper" Banff, *Rhipidomella* was commonly associated with large brachiopods, especially strophomenids and spiriferids. *Schizophoria* cf. *S. poststriatula* occurs in the *Calvustrigis rutherfordi* Zone of the eastern facies, most commonly in association with the productids *Piloricilla desmetensis* n. sp., *Ovatia prolata* n. sp., *Avonia? beckerensis* n. sp. and the spiriferids *Unispirifer greenockensis* (Brown) and *Calvustrigis rutherfordi* (Warren). It occurs in the "upper" Banff at Sunwapta Pass in association with *Tomiproductus gallatinensis* (Girty), *Unispirifer minnewankensis* (Shimer), *Spirifer mountraensis* n. sp., *Torynifer pseudolineatus* (Hall) and *Punctospirifer subtextus* (White). In both eastern and western facies it occurs with *Schellwienella* cf. *S. alternata* Weller and *Cleiothyridina lata* Shimer.

Strophomenids

A single strophomenid species, *Leptagonia missouriensis* Carter, occurs in the Banff Formation. All well documented occurrences of this species have been from the *Calvustrigis rutherfordi* Zone of both eastern and western facies. Shimer (1926) reported *Leptaena analoga* from his Bed 29 at Lake Minnewanka, but this occurrence and stratigraphic horizon have not been substantiated by subsequent collectors. The most common faunal associates of *Leptagonia* are *Piloricilla desmetensis* n. sp. and *Unispirifer greenockensis* (Brown), although many of the common species of the *Calvustrigis rutherfordi* Zone have also been found with it, but in fewer numbers.

Orthotetids

It is possible to differentiate at least four species of orthotetid in the Banff Formation. Three of these species are assigned to the genus *Schellwienella,* the most commonly occuring Lower Carboniferous orthotetid. A large species, referred here to *Schellwienella* cf. *S. alternata* Weller, characterizes both zones of the "upper" Banff member of the Bow River valley region. Although it is found occasionally with nearly all of the species common to the "upper" member, it is usually found in association with *Tomiproductus gallatinensis* (Girty), *Unispirifer minnewankensis* (Shimer), *Spirifer mountraensis* n. sp., *Torynifer pseudolineatus* (Hall), and *Verkhotomia jucunda* n. sp. One specimen assignable to this species was collected by R.A.C. Brown from the "middle" Banff in the Jasper region.

Schellwienella cf. *S. bushbergensis* Branson is restricted to the *Calvustrigis rutherfordi* Zone of both facies and is found in association with nearly all of the more common elements of this fauna. *Schellwienella* cf. *S. chouteauensis* Weller is restricted to the Bow River valley region, or western facies, but occurs sparsely in both the "middle" and "upper" members. Its occurrence is too sporadic to determine possible associations.

An unidentified species of *Streptorhynchus* occurs in the "middle" member of the eastern facies, Jasper region, in the *Calvustrigis rutherfordi* Zone.

Chonetids

None of the four Banff chonetids described in this report is found in large numbers, and only one, *Subglobosochonetes norquayensis* n. sp., is widely distributed throughout the Banff outcrop area. This species is stratigraphically restricted to the *Calvustrigis rutherfordi* Zone.

Two species of *Rugosochonetes* are present in the Banff fauna. A large form referred here to *Rugosochonetes* cf. *R. multicostus* (Winchell) is very rare and confined to the *Calvustrigis rutherfordi* Zone, but is found in both facies. The other rugosochonetid, *Rugosochonetes* cf. *R. loganensis* (Hall and Whitfield), is present in the *Stegacanthia* cf. *S. bowsheri-Marginatia ferniglenensis* Zone at Mount Rundle, its only documented "upper" Banff occurrence. However, this species is fairly common in the *Calvustrigis rutherfordi* Zone of both facies. It is commonly associated with the spiriferids *Prospira fessaulacis* n. sp., *Unispirifer greenockensis* (Brown) and *Punctospirifer solidirostris* (White). It should be noted that all three of the preceeding chonetids are found together in the "middle" member at the type section of the Banff Formation, Mount Rundle.

The fourth Banff chonetid described here is *Plicochonetes canadensis* n. sp. This species is known only from two horizons in the *Calvustrigis rutherfordi* Zone at Canyon Creek.

Productids

There are at least twenty-five productid taxa recognizable in the Banff fauna, and of these, twenty can be assigned to species in twelve genera. Two of the remaining species can be assigned at the generic level only, two at the family level, and one at the superfamily level only. Twelve species, or almost half of the total, belong to the Overtoniidae; three species to the Leioproductidae; two to the Tolmachoffiidae; two to the Echinoconchidae; four to the Buxtoniidae; and one to the Linoproductidae. Except for the lack of strophalosiaceans and productellids this is a fairly characteristic Lower Carboniferous productid fauna.

The Leioproductidae are represented by three species of the genus *Spinocarinifera* Roberts. *Spinocarinfera copiosa* n. sp. is the most common species in this group, occurring in many collections from the *Calvustrigis rutherfordi* Zone of the eastern facies and rarely in the same stratigraphic interval at Mount Rundle. This species, or a very similar taxon, is also common in the uppermost Pekisko Formation and lowermost Shunda Formation near Cadomin, Alberta. *Spinocarinifera* (*Seminucella*) *parva* n. subgen., n. sp., is a small, distinctive species that appears to be restricted to the eastern facies. It is common in the Jasper region but rare elsewhere, and is commonly associated with the much larger *Spinocarinifera copiosa* and the small rhynchonellid *Macropotamorhynchus insolitus* n. sp. *Spinocarinifera arcuata* (Hall) has been identified in the "middle" member by various authors, but it was found to be very rare in this study. Most specimens assigned by previous authors to this species probably belong to *Piloricilla desmetensis*.

The highly diverse Overtoniidae are represented by five genera and a dozen species. *Rugauris robusta* n. sp., *Semiproductus calhounensis* (Moore), *Avonia canyonensis* n. sp., *Avonia*? *beckerensis* n. sp. and *Stegacanthia gausapa* n. sp. are known only from the *Calvustrigis rutherfordi* Zone of the eastern facies. *Avonia banffensis* n. sp. ranges from the *Calvustrigis rutherfordi* Zone of the eastern facies into the "upper" member *Stegacanthia* cf. *S. bowsheri-Marginatia ferniglenensis* Zone of the western facies in the Bow River valley region. In addition, it is identified by R.A.C. Brown's collections from the upper Pekisko Formation of the Jasper region. The youngest species of *Avonia*, *A. minnewankensis* (Shimer), characterizes the youngest brachiopod zone of the "upper" Banff and is limited to that stratigraphic interval of the western facies. *Stegacanthia* cf. *S. bowsheri* Muir-Wood and Cooper, one of the name-givers for the lowest brachiopod zone of the "upper" Banff is apparently restricted geographically to the Bow River valley region. It first appears near the base of the "upper" member in this region and ranges into the lower part of the overlying zone. *Piloricilla desmetensis* n. gen. n. sp. is one of the most common productids in the Banff Formation. It is probably restricted to the *Calvustrigis rutherfordi* Zone, although a unique, very large specimen from the lowermost Shunda Formation of the Jasper region was noted in the collections of R.A.C. Brown. It is widely distributed in the *Calvustrigis rutherfordi* Zone of both facies and, apart from the possible exception noted above, appears to be an excellent indicator of this zone in western Alberta.

Two species of the tolmachoffiid genus *Setigerites* Girty are found in the Banff Formation. The very large *Setigerites newtonensis* Moore is known only from a single, well preserved specimen collected by the author from an indeterminate "upper" Banff horizon near the Bow River valley region (GSC loc. C-57474). It was found in association with very large specimens of *Spirifer mountraensis* n. sp. and an unusually large syringothyridid of indeterminate affinities. *Setigerites jasperensis* (Warren) is a fairly common element of the *Calvustrigis rutherfordi* faunal assemblage. In its typical form it is restricted to this zone in both facies, although it is very rare in the Bow River valley region. A very similar species, perhaps identical, is common in the uppermost Pekisko Formation and lowermost Shunda Formation near Cadomin, Alberta.

The Echinoconchidae are represented in the Banff Formation by two species of the genus *Pustula* Thomas. *Pustula* cf. *P. pustulosa* (Phillips) is known only from the "middle" Banff member at Mount Coleman and from one locality in the Jasper region. *Pustula morrocreekensis* n. sp. is a small, finely ornamented species that is rare, but fairly widely distributed in the *Calvustrigis rutherfordi* Zone of the Jasper region.

There are three genera of the Buxtoniidae to be considered here. *Tomiproductus gallatinensis* (Girty) is widely distributed in the upper Banff Formation and lower Rundle Group of the Jasper region, but so far is known only from a fairly thin stratigraphic interval in the "upper" member of the Bow River valley region. The smaller but similar Madison species *Tomiproductus parviformis* (Girty) has not been recovered from the Banff Formation so far, but is quite common in the Pekisko and Shunda formations. An undescribed new species of the distinctive genus *Flexaria* Muir-Wood and Cooper is known from a single specimen. It was collected by P. Harker from the "upper" Banff at Sunwapta Pass, Alberta. This specimen may represent the earliest occurrence of this genus in North America.

In this paper, only a few species described from the midcontinental Mississippian are recognized from the Banff Formation and considerable biostratigraphic significance is attached to them. The highly diagnostic species *Marginatia burlingtonensis* (Hall) and *Marginatia ferniglenensis* (Weller) both occur in the "upper" member of the Bow River valley region, and in fact, are name-givers for the upper two

brachiopod zones of the Banff Formation. Although the two species do not occur together in any single collection, their overall distribution in the Bow River valley region suggests that their stratigraphic ranges may overlap. *Marginatia ferneglenensis* occurs in association with *Stegacanthia* cf. *S. bowsheri* in Alberta, as it does in the midcontinent. At some localities, *Marginatia burlingtonensis* is common in the upper several hundred feet of the Banff Formation of the western facies. It ranges into the Lower Livingstone Formation, virtually always in association with the large *Spirifer mountraensis* n. sp.

A single linoproductid, *Ovatia prolata* n. sp., ranges throughout the *Calvustrigis rutherfordi* and lower *Stegacanthia* cf. *S. bowsheri-Marginatia ferneglenensis* zones. This species is particularly common in the eastern facies.

Rhynchonellids

This order is represented by a diverse group of eight species assigned to six distinctive genera. The occurrence of rhynchonellids in the Banff Formation is sporadic and only two of the eight species are reasonably plentiful.

The Trigonorhynchiidae include five species belonging to three genera. Two species of the genus *Hemiplethorhynchus* von Peetz are found in the *Calvustrigis rutherfordi* Zone of the Jasper region, sometimes associated in the same collections. *Hemiplethorhynchus allani* (Warren) is restricted to this zone and also occurs in it in the Bow River valley region. *Hemiplethorhynchus snaringensis* (Brown) appears to occur only in the eastern facies of the Jasper region and the foothills east of Jasper. Although this species is fairly common in the *Calvustrigis rutherfordi* Zone, R.A.C. Brown made a sizable collection of this, or a very similar but somewhat larger species, from the lowermost Shunda Formation near Jasper. *Moorefieldella prisca* n. sp. is a rare but distinctive trigonorhynchiid found mainly in the *Calvustrigis rutherfordi* Zone of the eastern facies. A single specimen from the "upper" member at Grotto Mountain in the Bow River valley may belong here. This genus has been described previously only from Upper Mississippian strata. Two other trigonorhynchiids are assigned to the genus *Macropotamorhynchus* Sartenaer. *Macropotamorhynchus insolitus* n. sp. is a small, highly variable species commonly found in the *Calvustrigis rutherfordi* Zone in both facies. In addition, it is much less commonly found in the "upper" member of the western facies, extending into the lower part of the *Avonia minnewankensis-Marginatia burlingtonensis* Zone. *Macropotamorhynchus curiosus* n. sp. is a peculiar asymmetrical species known only from one horizon in the *Calvustrigis rutherfordi* Zone of the eastern facies. It is found in association with *Eumetria osagensis* and *Composita humilis*.

Two genera of the Pugnacidae are found in the Banff Formation. *Shumardella pygmaea* n. sp. is a small form that is apparently restricted to the *Calvustrigis rutherfordi* Zone of the eastern facies. It is found in association with another very rare species, *Hustedia circularis*. *Ningbingella*? cf. *N. boonensis* (Shumard) is an extremely rare species known only from the "middle" member at Mount Rundle.

One of the most characteristic species in the *Calvustrigis rutherfordi* faunal assemblage is the distinctive tetracamerid *Axiodeaneia usheri* (Brown). This species is fairly common in the eastern facies at many localities but is apparently not present in the western facies.

Retziids

Of the two species of retziid found in the Banff Formation only *Eumetria osagensis* (Swallow) is reasonably common. It is a typical element in the *Calvustrigis rutherfordi* assemblage but is also found occasionally in the lower Rundle Group and "upper" member of the Banff. *Hustedia circularis* (Miller) is a very rare, tiny retziid from the *Calvustrigis rutherfordi* Zone of both facies.

Athyridids

This is one of the larger and best represented groups of brachiopod in the Banff Formation, with eleven known species differentiated for this report. As one would expect, the genera *Cleiothyridina* and *Composita* dominate the species list but there is also an interesting representative of the hitherto unreported genus *Pseudopentagonia* present.

Four Banff species are assigned to the genus *Cleiothyridina*. The most common by far is *Cleiothyridina lata* Shimer, a large, distinctive form sometimes confused with midcontinental species such as *C. obmaxima* (McChesney). *Cleiothyridina lata* is likely to be found at any Banff horizon and locality, except perhaps the uppermost beds of the western facies. *Cleiothyridina tenuilineata* (Rowley) is a small subcircular species that is moderately common in the *Calvustrigis rutherfordi* Zone of the Jasper region and rare in the "middle" member at Mount Rundle. It also occurs sporadically in the "upper" member in the Bow River valley region and Lower Rundle Group in the Jasper region. *Cleiothyridina harkeri* n. sp. is a rare, large, transverse species from the "upper" member. Its distribution and stratigraphic range are poorly known. *Cleiothyridina miettensis* n. sp. is another rare species. This tiny *Cleiothyridina* is known from a single collection from the *Calvustrigis rutherfordi* Zone near the Miette Hot Springs, Jasper Park.

The genus *Composita* is represented by five species, one of which is new. *Composita athabaskensis* Warren is a very common species in the *Calvustrigis rutherfordi* Zone of the eastern facies but it is not reported in the Bow River valley region or anywhere else in the western facies. Two species originally described by Girty (1899) from the Madison Limestone are found in the Banff Formation. *Composita humilis* (Girty) is a small broad *Composita* that is fairly common in the *Calvustrigis rutherfordi* Zone of the Jasper region and other parts of the eastern facies. In the Bow River valley region it occurs in the "upper" member at one locality. *Composita immatura* (Girty) is a highly inflated elongate species found only in the *Calvustrigis rutherfordi* Zone of the eastern facies, occurring mostly in the Jasper region. *Composita* cf. *C. oblonga* (Tolmachoff) is a rare form found at only three localities, all in the "middle" Banff *Calvustrigis rutherfordi* Zone. Two collections are from the Miette Hot Springs area of the eastern facies and the other is from Mount Rundle. *Composita prolixa* n. sp. is a rare species also known from only three localities, all from the *Calvustrigis rutherfordi* Zone of the eastern facies.

The most unusual athyridid in the Banff fauna is a small, strongly folded species that is comparable to the genus *Pseudopentagonia* Beznosova. The comparative identification is based on a single, reasonably well preserved, nearly complete specimen from the *Calvustrigis rutherfordi* Zone of the Jasper region.

A distinctive athyridid species of indeterminate affinities occurs only at GSC locality 18788, Jasper Park.

Impunctate spiriferids

In specific diversity and total numbers, the members of this order rival the productids, with twenty-four species and hundreds of specimens from many localities. Sixteen genera are placed in eight families, the largest of which is the Spiriferidae. Although sometimes difficult to identify specifically, spiriferids are among the most useful Banff brachiopods for biostratigraphic purposes. Even so, there is little convincing evidence that evolutionary trends or true lineages can be demonstrated in this particular faunal succession.

Two Banff species are attributed to the Ambocoeliidae, although only one, *Crurithyris* cf. *C. laevicula* (Weller), is recognized as a definite member of the Banff fauna. Shimer's *Ambocoelia magna* is not accepted as a recognizable species in this report and is considered to be a *nomen dubium*. *Crurithyris* cf. *C. laevicula* (Weller) is known only from the *Calvustrigis rutherfordi* Zone of the eastern facies, although it should be noted that a similar *Crurithyris* occurs in the lower Rundle Group of the Jasper region. *Crurithyris* cf. *C. laevicula* is associated with *Podtsheremia*? *albertensis* in three of the five collections available. In one collection it is found only with inarticulates. In the fifth collection the *Crurithyris* is the only fossil noted.

The new licharewiid genus *Calvustrigis*, based on *Spirifer rutherfordi* Warren, is the sole representative of the family in the Banff Formation. The Licharewiidae are previously unreported in the Mississippian of North America. The type species of this new genus is the name-giver for the large brachiopod assemblage that characterizes the upper Banff beds of the Jasper region and is one of the most common and readily recognized species in this stratigraphic interval of the eastern facies. Although it has been reported from the western facies in published fossil lists, the author saw no authentic specimens from the western facies.

The Spiriferidae are the most predominant specimens in the Banff spiriferid fauna, consisting of ten species in five genera. *Voiseyella texana* (Carter) is a very rare, small strophopleurinine known only from a few specimens, all from the "upper" member of the western facies. Two species are assigned to the small, common genus *Prospira* Maxwell. *Prospira* cf. *P. albapinensis* (Hall and Whitfield) is sporadic in occurrence throughout western Alberta, being somewhat more rare in the "upper" member than in the generally more fossiliferous *Calvustrigis rutherfordi* Zone. *Prospira fessaulacis* n. sp. is another small species, but it is restricted to the *Calvustrigis rutherfordi* Zone. It is known from one locality in the western facies, but is fairly common in the eastern facies, where it is commonly associated with the productid *Piloricilla desmetensis*. Apparently, it is rarely associated with the other *Prospira* species discussed above. Some of the more numerous small spiriferids in the Banff are two species of the genus *Unispirifer* Campbell. *Unispirifer greenockensis* (Brown) is a common element in the *Calvustrigis rutherfordi* assemblage of both facies. It is replaced by *Unispirifer minnewankensis* (Shimer) in the uppermost *Calvustrigis rutherfordi* Zone or lower *Stegacanthia* cf. *S. bowsheri-Marginatia ferrglenensis* Zone. In some cases, the ranges of the two appear to overlap slightly, but they never occur together, with one possible exception in an R.A.C. Brown collection from the Jasper area. A possible derivative of *Unispirifer greenockensis* is a common species in the uppermost Pekisko Formation and lowermost Shunda Formation near Cadomin, Alberta. The third species assigned to this genus, *Unispirifer rundlensis* (Warren), was based on specimens from the lower Livingstone Formation at Mount Rundle. The only collection of this species attributed to the Banff Formation consists of three specimens collected by P. Harker at Mount Rundle from the "upper" member.

The "upper" member of the Banff has a brachiopod fauna dominated by a large, usually crushed and poorly preserved species of the genus *Spirifer* s.s. This species, named *Spirifer mountraensis* here, is the large spiriferid referred to as *Spirifer grimesi* or *Spirifer rowleyi* by most previous authors. Restricted to the western facies, this species ranges throughout both "upper" member zones and well into the lower Livingstone Formation.

The common larger spirifer in the *Calvustrigis rutherfordi* assemblage is *Spirifer esplanadensis* Brown. It is very common in the eastern facies but rare in the "middle" member of the western facies. It appears to be derived from the *Spirifer gregeri-Spirifer rowleyi* group of the midcontinent, but its morphology and ornamentation do not suggest ancestry to the larger *S. mountraensis* from younger beds. A very small, unnamed species or subspecies derived from *S. esplanadensis* does occur near the top of the "upper" member at one locality in the Bow River valley. *Spirifer cascadensis* Warren, the remaining species assigned to this genus, was described by Warren (1927) from the "middle" member at Mount Rundle. This readily recognized species is not abundant in any collection studied for this report, but does occur with moderate frequency throughout the eastern facies in the *Calvustrigis rutherfordi* Zone. In the western facies, it ranges well into the *Stegacanthia* cf. *S. bowsheri-Marginatia ferrglenensis* Zone.

Podtsheremia? *albertensis* (Warren) is a common spiriferid of the *Calvustrigis rutherfordi* Zone in the eastern facies. It has sometimes previously been identified as *Spirifer missouriensis* Swallow, a very similar species from Kinderhookian strata of the midcontinent. A large, robust variety of *P.*? *albertensis*, reminiscent of *Spirifer vernonensis* Swallow, another midcontinental species of Osagean age, can be found in the uppermost Pekisko Formation and lowermost Shunda Formation near Cadomin, Alberta.

Brachythyridids are scarce in the Banff Formation, although it is possible to differentiate three species belonging to two genera. *Brachythyris chouteauensis* Weller is identified in four collections from the *Calvustrigis rutherfordi* Zone of the eastern facies, and in two collections from the "upper" member of the Bow River valley region. *Brachythyris* cf. *B. chouteauensis* refers to a poorly known species from the *Calvustrigis rutherfordi* Zone in the northern part of the eastern facies. It is known from only two specimens from different localities. *Skelidorygma bamberi* n. sp. is also a rare species. Solitary specimens from two localities in the *Calvustrigis rutherfordi* Zone, one specimen from the "upper" member at Sunwapta Pass, and several specimens from the "upper" member at Tunnel Mountain near Banff constitute all the known specimens of the species.

Several reticulariaceans are reasonably common in both facies of the Banff Formation. Of the Elythidae, *Torynifer pseudolineatus* (Hall), a common Osagean species in the midcontinent, occurs sporadically throughout most of the "upper" member of the western facies and also in the lower Rundle Group of both facies. At two localities in the eastern facies this species apparently occurs in the *Calvustrigis rutherfordi* Zone. *Torynifer eufastigium* n. sp. is a

moderately large, transverse species, restricted to the *Calvustrigis rutherfordi* Zone of the eastern facies. It may have given rise to *T. pseudolineatus*, for which there are no suitable antecedents in the midcontinent. *Kitakamithyris cooperensis* (Swallow), a smaller elythid, is commonly found in the Kinderhookian of the midcontinent. In western Alberta, it occurs sparsely in the *Calvustrigis rutherfordi* Zone of the eastern facies.

As is usual in Tournaisian strata, the Martiniidae are not a common faunal constituent. *Eomartiniopsis rostrata* (Girty), the sole representative of this family in the Banff, is moderately common in the *Calvustrigis rutherfordi* Zone of the eastern facies and is a less common faunal element in the same zone at Lake Minnewanka. In the western facies it ranges into the *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone of the "upper" member.

Punctate spiriferids

There are four punctate spiriferids in the Banff brachiopod fauna, two belonging to the Spiriferinidae and two to the Syringothyrididae. The spiriferinid genus *Punctospirifer* North is moderately abundant, particularly the species *P. solidirostris* (White), a common Kinderhookian form in the midcontinent. *Punctospirifer solidirostris* is present in many collections from the *Calvustrigis rutherfordi* Zone of both facies. It is also present in one of R.A.C. Brown's lower Rundle collections from the Jasper region. *Punctospirifer subtexta* (White), a species described from the early Osagean of the midcontinent, is much less common, occurring in the "upper" member at only two localities, both from the western facies. In the Jasper region this species can also be found in the lower Rundle Group. Although it is possible that the stratigraphic ranges of the two overlap, they are not known to occur together in the collections available.

The family Syringothyrididae has two representatives in the Banff Formation, both with a distinctive and easily recognized morphology. *Syringothyris* cf. *S. hannibalensis* (Swallow) is externally comparable to the well known Upper Devonian species originally described from the Louisiana Limestone of Missouri. It occurs at many localities in the eastern facies and appears to be restricted to the *Calvustrigis rutherfordi* Zone, with one possible exception, noted below. It is also found in this stratigraphic interval at two localities in the western facies. A similar, but much smaller variety, possibly the same species, occurs in the lower Rundle Group in the Jasper region and at the top of the "upper" Banff member at one locality in the Bow River valley. *Verkhotomia jucunda* n. sp. is a large, transverse species found only in the "upper" member of the western facies. It ranges throughout the "upper" member and well into the lower Livingstone Formation. It is usually associated with the large spiriferid *Spirifer mountraensis*, and somewhat less frequently with the large orthotetid *Scheliwienella* cf. *S. alternata* and the smaller spiriferid *Unispirifer minnewankensis*.

Terebratulids

Although four distinct species have been differentiated, none of the Banff terebratulids is abundant or has been studied thoroughly. Three genera and four species can be identified, mainly from internal morphology, but only one species appears to be indistinguishable from a previously described species. A *Cranaena* species, externally comparable to the Texas species, *C. texana* Carter, is found in small numbers in the *Calvustrigis rutherfordi* Zone of both facies. More complete specimens will have to be obtained before it can be identified satisfactorily. The well known midcontinental species *Beecheria chouteauensis* (Weller) is identified at several localities in western Alberta. In the eastern facies, it has been found only in the *Calvustrigis rutherfordi* Zone, whereas in the western facies it seems to be present only in the "upper" member. The genus *Dielasma* is very rare in the Banff fauna. Only two specimens are available and both these were sectioned in order to obtain information about the internal morphology. These specimens are clearly not conspecific although they are of similar age, both being recovered from the *Calvustrigis* Zone of the eastern facies.

Correlation with the midcontinent

In Figure 4, the correlation of the Banff Formation with the standard section of the Mississippian System in the midcontinent is indicated. Correlation of the middle and upper Banff strata that contain significant numbers of macrofossils is based upon both the brachiopod zones presented in this report and the conodont zones determined by Baxter (1972) and Baxter and von Bitter (1984). Correlation of the lower Banff beds, which lack significant macrofossils, is by means of these conodont zones alone. Although the Mississippian System in its type area has not been formally zoned in the modern sense by means of brachiopods, the vertical ranges of many species are reasonably well documented both in museum and university collections and in the published works of Rowley (1908), Weller (1909, 1914), Van Tuyl (1925), and Moore (1928). Weller's (1926) generalized zonation based on various megafossils was not properly defined or supported by adequate documentation. It has not been considered here because his lower two zones are essentially equivalent to the Kinderhookian and Osagean stages and provide inadequate biostratigraphic resolution for the purposes of this report.

Correlation of the *Calvustrigis rutherfordi* Assemblage Zone with the brachiopod fauna described by Carter (1972) from the Gilmore City Limestone of north-central Iowa is based on mutual occurrences of several distinctive species of restricted stratigraphic range as well as overall faunal similarity, which in this case does not reflect similar environments of deposition. The brachiopod-bearing beds of the Gilmore City Limestone at its type locality are very shallow water dolomitic and oolitic limestones that reflect restricted circulation. The middle Banff facies, on the other hand, is interpreted by Macqueen and Bamber (1967, p. 13) as representing somewhat deeper water, offshore, open marine carbonates with some local shoaling, but with open marine faunas. Eighty-six per cent of the Gilmore City brachiopod genera also occur in the *Calvustrigis* assemblage of Alberta and most Gilmore City species are identical or have close analogues with the Alberta assemblage.

There is a recently discovered, slightly younger Gilmore City brachiopod faunule, possibly of early Osagean age, that cannot be readily correlated with the upper Banff brachiopod zones or the Mississippi Valley section.

The *Calvustrigis rutherfordi* Assemblage Zone can also be traced into the Eagle City Limestone Member of the Hampton Formation of central Iowa, which Thomas (1960) and Carter (1972) believe to be a facies of some part of the Gilmore City Limestone.

In the Mississippi Valley region, the *Calvustrigis rutherfordi* Assemblage Zone, or its equivalent, is lacking, as is its temporal conodont equivalent, the *Siphonodella cooperi hassi-Gnathodus punctatus* Zone of Thompson and Fellows (1970). Laudon (1931), Collinson et al. (1962), and others have noted this depositional hiatus at the top of the Kinderhookian, demonstrating the presence of a major unconformity between the Kinderhookian and Osagean in southeastern Iowa and western Illinois.

Assignment of the *Calvustrigis rutherfordi* Zone to either Lower Mississippian series is difficult. Laudon (1933, p. 7) and Carter (1972, p. 476) assigned the Gilmore City Limestone macrofauna to the uppermost Kinderhookian on the basis of overall faunal similarity to older faunas. However, Lane (1974, p. 277) has succinctly suggested that the *Siphonodella cooperi hassi-Gnathodus punctatus* Zone be placed at the base of the Osagean. Therefore, the assignment of the *Calvustrigis* Zone to one Lower Mississippian series or the other is still equivocal.

The two "upper" Banff brachiopod zones of this report are clearly Osagean in age. The *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Range Zone correlates readily with the Meppen, Fern Glen, lower Burlington, and Pierson formations of Missouri. This zone is missing in its entirety in southeastern Iowa. Both of the name-givers are found in the lower Burlington and Pierson formations but *Stegacanthia* cf. *S. bowsheri* has not been identified in the Fern Glen Formation so far. Just as in Alberta, *Stegacanthia* cf. *S. bowsheri* may range into the lower part of the succeeding Range Zone in the midcontinental region. The other name-giver, *Marginatia fernglenensis*, is very common in all three of the Missouri formations and appears to be restricted to this zone in the midcontinent, although it ranges upward into the lower *Avonia minnewankensis-Marginatia burlingtonensis* Zone in Alberta.

The upper limits of the youngest Banff brachiopod zone, the *Avonia minnewankensis-Marginatia burlingtonensis* Range Zone, cannot be precisely correlated with the standard section, although it certainly occurs within the time range of the "upper" Burlington Limestone in southeastern Iowa.

In southeastern Iowa and northeastern Missouri, a massive bedded, coarse grained "lower" Burlington unit, variously named the "White Ledge" (Rowley, 1908), the *Cactocrinus* Zone (Rowley, 1908; Laudon, 1937), or the Dolbee Creek Member (Harris and Parker, 1964), occurs at the top of the "lower" Burlington Limestone sequence. Although neither species of *Marginatia* discussed above apparently occurs in this unit, at least as far as the author can determine, an *Avonia*, possibly identical with *Avonia minnewankensis* (Shimer) does occur. This rare distinctive *Avonia*, described by Sutton (1942) as *Avonia linospinosa*, first appears in the "white chert" beds of the *Cryptoblastus* Zone (Laudon, 1937) immediately below the "White Ledge", ranging well up into the latter.

Marginatia burlingtonensis (Hall) first occurs in abundance in the lower beds of the overlying "upper" Burlington (Haight Creek Member in southeast Iowa). Therefore, it is likely that the lower boundary of the Banff Formation *Avonia minnewankensis-Marginatia burlingtonensis* Zone occurs no lower than the Dolbee Creek Member or "White Ledge" and no higher than the base of the Haight Creek Member in the standard section region of the upper Mississippi Valley.

The Gilmore City Limestone – middle Banff Formation faunal affinities, and the distribution of several distinctive Osagean midcontinental species in the upper Banff suggest that some marine communication, albeit brief, must have existed at one or more times between the midcontinent and the northern Cordilleran region during Early Mississippian time. The strong Banff aspect of the Gilmore City Limestone fauna of north-central Iowa suggests that the Transcontinental Arch was breached briefly in late Kinderhookian or early Osagean time.

The upper Banff fauna is much less diverse than the *Calvustrigis* assemblage, and over half of the common brachiopod species are endemic to the Cordilleran region. However, a significant number of species are identical or closely related to species in the type Mississippian region, which also implies the presence of a marine connection in Osagean time. Lane and De Keyser (1980) have proposed that the early Tournaisian westward transgression of the midcontinental carbonate shelf resulted in the deposition of similar shelf carbonates from the upper Mississippi Valley to southern New Mexico. They concluded that the only possible unrestricted connection between these shelf deposits east of the Transcontinental Arch and those of the Cordilleran shelf west of the arch was to the south of the arch in Osagean time. This circuitous connection, if it occurred, could account in large part for the dissimilarity in the brachiopod faunas between the two regions in Osagean time.

Correlation with the Cordilleran region of the United States

The Banff Formation of western Alberta is very similar to, and was continuous with, much of the Madison Group carbonate sequence in the United States. The Banff-Madison rocks in the Cordilleran region near the international border have been removed by erosion, which accounts in some measure for the dual stratigraphic nomenclature. It is generally agreed that the Banff Formation at and near Mount Rundle can be approximately correlated with, and is of the same general sedimentary facies as, the Lodgepole Formation of the Madison Group in Montana. Although most macrofaunas are poorly known in both formations, Sando et al. (1969, p. E22) found the same foraminiferal assemblages in the Woodhurst Limestone Member of the Lodgepole Formation of Montana and in the upper Banff Formation, lower Livingstone Formation and Pekisko Formation of Alberta.

Brachiopods may be of considerable value for accurate correlation between the Banff and Lodgepole formations. However, much of the Lodgepole brachiopod fauna is undescribed. Of the species described, about two dozen are identical, or have close affinity with, Banff species. No previously described Banff species is reported from the Lodgepole in published reports.

Although reliable brachiopod-based correlations are not possible at this time, the brachiopods listed from Sando, Mamet, and Dutro's (1969) Zone B are suggestive of the *Calvustrigis rutherfordi* Zone as used in this paper. Their Zone C_1 faunal list is suggestive of both of the upper Banff brachiopod zones used here, which are of early to middle Osagean age.

Even less published faunal data is available for other Lower Mississippian brachiopod faunas from the southern Rockies or Alaska and pertinent brachiopod comparisons are not possible.

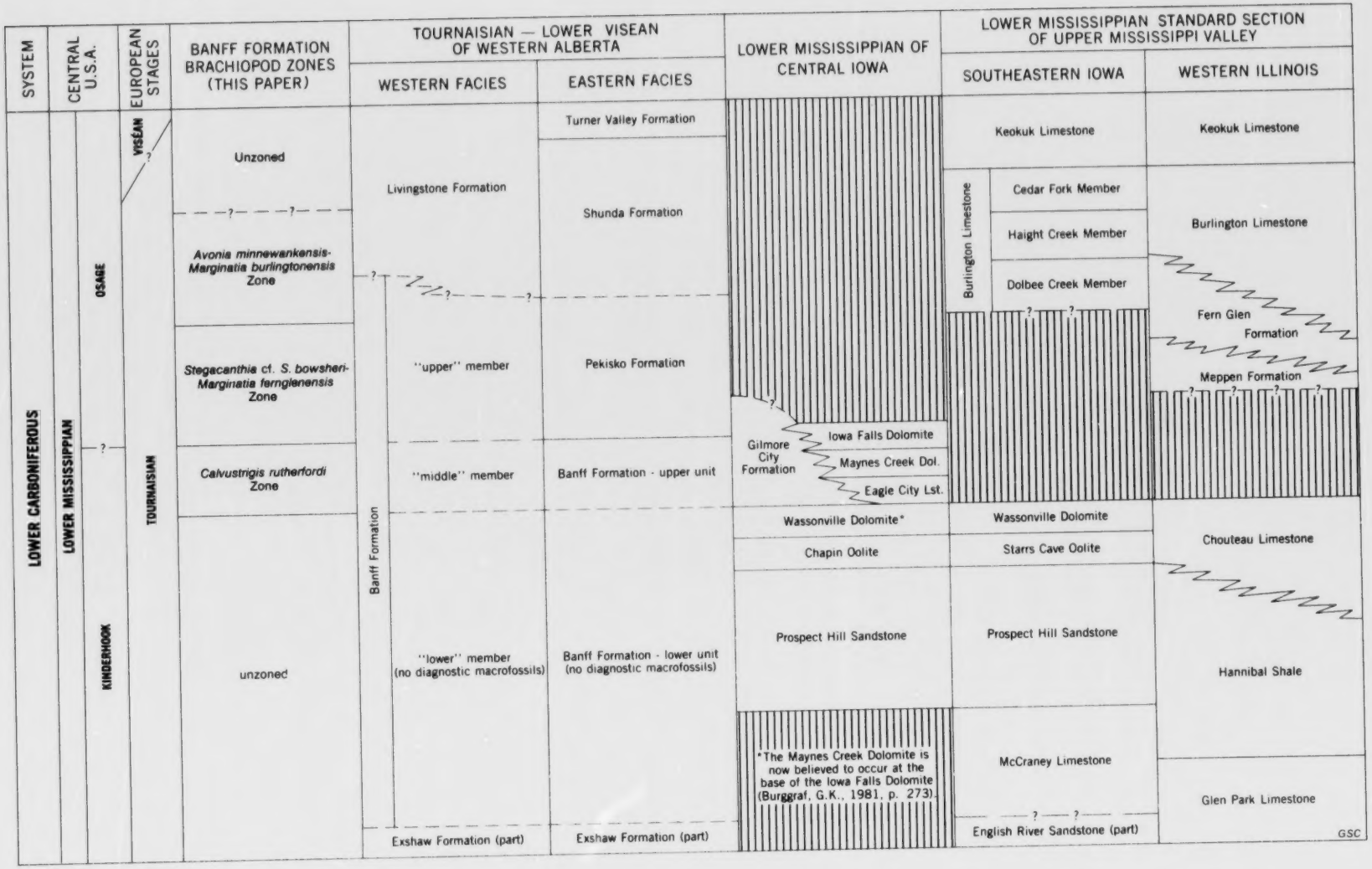

Figure 4. *Correlations of the Banff Formation with strata of the North American midcontinent.*

Affinities with the Tournaisian faunas of the Kuznets Basin

The Banff brachiopod fauna is remarkably similar to the Tournaisian faunas from the Kuznets Basin of southwestern Siberia as described and illustrated by Sarycheva et al. (1963), and comparable faunas from southeastern Kazakhstan described by Bublichenko (1976). Of the 52 Banff brachiopod genera considered here, 41 are also found in the Kuznets Tournaisian faunas. Twenty-five Banff species are very similar or identical to Kuznets species. Mamet and Skipp (1979) recognized similar faunal affinities between Cordilleran and Siberian Carboniferous Foraminifera and termed this geographic distribution the Kuznets-North America Realm. Although much of the Lodgepole brachiopod fauna remains to be described, the Kuznets brachiopods appear to indicate as close an affinity with the Banff faunas as do those of the Lodgepole, although description of the latter fauna may considerably alter this picture.

A recent reassembly of the Paleozoic continental plates (see Scotese et al., 1979, figs. 26-31) does not show a direct link between southern Siberia, eastern Kazakhstan, and the North American Cordilleran region in Early Carboniferous time. Although Scotese et al. do indicate a direct connection between Siberia and Kazakhstania in Westphalian time, they indicate an increasing gap between the northern Cordilleran region and Siberia-Kazakhstania. However, the brachiopod and foraminiferal evidence cited above definitely suggests relatively free faunal exchange between these regions in Early Carboniferous time.

SYSTEMATIC PALEONTOLOGY

In this section only selected references are cited for previously described species. There are objective synonymies up to 1968 in Weller (1898) and Carter and Carter (1970).

Because complete uncrushed valves are so rare for most species, measurements are, in most cases, given only for types and referred specimens.

All types and referred specimens of newly described species are deposited with the Geological Survey of Canada, Ottawa, and the bulk of the non-type specimens are in the collections of the Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, Calgary.

Phylum BRACHIOPODA Duméril, 1806

Class INARTICULATA Huxley, 1869

Order LINGULIDA Waagen, 1885

Superfamily LINGULACEA Menke, 1828

Family LINGULIDAE Menke, 1828

Genus *Lingula* Bruguière, 1797

Lingula sp.

Plate 1, figures 1, 2

Remarks. This genus is very rare in the Banff Formation. Only two specimens have been examined by the author: one small disarticulated valve from GSC locality 18852, and what appears to be a pair of nearly articulated, incomplete valves from GSC locality 31367. Both specimens are small for the genus, rather poorly preserved, and cannot readily be assigned to a species. The specimen from GSC locality 31367 is the larger of the two and appears to have the posterior portion of one valve displaced posteriorly several millimetres, covering the beak of the other, nearly complete, valve. The smaller specimen from GSC locality 18852 appears to be slightly crushed, producing several, indistinct, irregularly spaced, longitudinal ribs. Most of the shell material is missing from the middle part of the valve in this specimen.

Order ACROTRETIDA Kuhn, 1949

Suborder ACROTRETIDINA Kuhn, 1949

Superfamily DISCINACEA Gray, 1840

Family TREMATIDAE Schuchert, 1893

Subfamily ORBICULOIDEINAE Schuchert and LeVene, 1929

Genus *Orbiculoidea* d'Orbigny, 1847

Orbiculoidea sp.

Plate 1, figures 3, 4

Remarks. Two specimens from GSC locality 31367 – interiors of both a pedicle and a brachial valve – appear to be assignable to this genus. Neither specimen is particularly well preserved and both are smaller than usual for the genus. The brachial valve forms a very low conical depression with a moderately blunt, posteriorly placed apex. The pedicle valve is substantially smaller than the other valve, more deeply depressed in the matrix, and possesses a closed, elongate, pedicle slit. Only a simple concentric ornament is preserved in either valve.

Class ARTICULATA Huxley, 1869

Order ORTHIDA Schuchert and Cooper, 1932

Suborder ORTHIDINA Schuchert and Cooper, 1932

Superfamily ENTELETACEA Waagen, 1884

Family ENTELETIDAE Waagen, 1884

Subfamily SCHIZOPHORIINAE Schuchert and LeVene, 1929

Genus *Schizophoria* King, 1850

Schizophoria cf. *S. poststriatula* Weller, 1914

Plate 1, figures 6-10

1914 *Schizophoria poststriatula* Weller, p. 165-167, Pl. 22, figs. 7-14.

Remarks. The genus *Schizophoria* is not common in the Banff Formation of Alberta. Only a few specimens are known, the best of these being a large, complete, slightly crushed shell from Sunwapta Pass, GSC locality 18527. This well preserved

specimen is compared with *Schizophoria poststriatula* Weller, described from the Fern Glen Formation and lower Burlington Limestone of Missouri. It is similar in external morphology, particularly in having a distinct ventral sulcus and dorsal fold. The Sunwapta Pass specimen differs mainly in being substantially larger than Weller's types or other Fern Glen specimens that have been observed by the author.

None of the other specimens of this genus from various other localities is well enough preserved to be worthy of description.

Distribution. Specimens of this genus have been recovered from three localities in the eastern facies, *Calvustrigis rutherfordi* Zone: GSC localities 49692, 74866 and C-7382. Only the specimen described above from Sunwapta Pass (GSC loc. 18527) is available from the western facies. It was probably recovered from the *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone.

Family RHIPIDOMELLIDAE Schuchert, 1913

Genus *Rhipidomella* Oehlert, 1890

Rhipidomella sp.

Plate 1, figure 5

Remarks. Few rhipidomellid specimens have been found in the Banff Formation. Two incomplete, disarticulated, silicified specimens from GSC locality 69567 can be assigned to this genus with confidence. The best specimen from this collection, a nearly complete pedicle valve, is illustrated here. Various other rhipidomellas are available for study from other localities and horizons. None of the specimens available is well enough preserved or sufficiently consistent in morphology to suggest a specific identification.

Distribution. Rhipidomellids occur sporadically throughout the Banff Formation in Alberta from the following localities and horizons: eastern facies (*Calvustrigis rutherfordi* Zone) GSC localities 49719 and 49737; western facies GSC locality 69554 (*Calvustrigis rutherfordi* Zone); GSC localities C-57470 and C-57471 (*Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone); GSC locality 74893 (*Avonia minnewankensis-Marginatia burlingtonensis* Zone); GSC locality 69567 (zone not determined).

Order STROPHOMENIDA Öpik, 1934

Suborder STROPHOMENIDINA Öpik, 1934

Superfamily STROPHOMENACEA King, 1846

Family LEPTAENIDAE Hall and Clarke, 1894

Genus *Leptagonia* M'Coy, 1844

Leptagonia missouriensis Carter, 1968

Plate 1, figures 11-15

1952 *Leptaena analoga* (Phillips). Brown, p. 85-86.

1961 *Leptaena analoga* (Phillips). Nelson, Pl. 4, fig. 26.

1968 *Leptagonia missouriensis* Carter, p. 1142-1143, Pl. 148, figs. 1-14.

Diagnosis. This species is characterized by its moderate size, subquadrate outline, small subangular ears, and moderately coarse rugae on the visceral disc of the pedicle valve with the trail distinctly defined by an enlarged ruga. The dorsal visceral disc is flat or weakly concave.

Remarks. Well preserved representatives of this species are not common in the Banff Formation, but the specimens available generally correspond with the diagnosis given above. Several of the Banff specimens are larger than usual for this species in collections from the midcontinent. The Banff specimens exhibit more variability in the number and coarseness of the rugae of the visceral disc. In this respect, the Banff specimens are similar to *Leptagonia cooperi* Sanders from the Represo Limestone of Sonora, Mexico. However, the latter seems to have much larger, more broadly tapered, acute lateral extremities. Unfortunately, the Represo species is known from only a few fragmentary specimens.

Shimer (1926, p. 32, 33) reported a single leptaenid specimen from a bed possibly assignable to the "upper" Banff as used in this report: Shimer Bed 2-29. Although Shimer applied the name *Leptaena analoga* (Phillips) to this specimen, it may belong to *L. missouriensis* Carter.

Distribution. With the exception of the Shimer specimen noted above, all of the other specimens studied for this report were recovered from the *Calvustrigis rutherfordi* Zone of the eastern facies: GSC localities 18550, 49733, 49741, 66327, 68449, 68452 and 74866.

Suborder ORTHOTETIDINA Waagen, 1884

Superfamily ORTHOTETACEA Waagen, 1884

Family SCHUCHERTELLIDAE Williams, 1953

Subfamily PULSIINAE Cooper and Grant, 1974

Genus *Schellwienella* Thomas, 1910

Schellwienella? cf. *S. alternata* Weller, 1914

Plate 1, figures 26, 27

1914 *Schellwienella alternata* Weller, p. 66-67, Pl. 4, fig. 6.

Description. Larger than average for genus, weakly to moderately convexo-concave; outline subquadrate; wider than long, greatest width attained near mid-length or slightly posteriorly; body cavity moderately thin; ornament parvicostellate, consisting of numerous, fine, straight, primary costae originating at protegulal node, with first and second order intercalated costellae rapidly attaining similar size to primary costae well before reaching anterior margin; third order costellae usually much finer than other ribs, commonly alternating with them at anterior margin; intercostal furrows with raised, posteriorly convex, concentric growth lamellae; growth lamellae not raised and commonly obscure on crests of ribs; strong irregularly spaced growth varices usually present in anterior third of valves, generally much weaker and more widely spaced posteriorly.

Pedicle valve weakly convex in umbonal region, becoming weakly concave anteriorly and flattened laterally;

small auriculations produced at cardinal extremities; beak very small and regular with no indication of cementation; ventral interarea flattened, strongly apsacline, low, acutely triangular, marked by transverse, parallel, irregularly spaced, moderately strong growth varices; pseudodeltidium wide, moderately convex, marked by numerous irregular growth lines; teeth of moderate length; internal details not observed.

Brachial valve evenly and weakly convex medially, or slightly more convex anteriorly, with lateral extremities defined by weakly concave flexures; very weak sulcus developed in umbonal region of some specimens; cardinal extremities subangular or subrounded; dorsal interarea low, weakly concave, catacline; chilidium forming narrow ribbon-like band around base of cardinal process; cardinal process low, stout, bilobed, laterally buttressed; internal details not observed.

Dimensions (mm).

GSC no.	Valve	Length	Width
10061a	Pedicle	46.2	59.4
10061b	Brachial	45.0	±60.0

Distinguishing characteristics. This species can be identified by its large size, subquadrate outline, low convexity of the brachial valve, weakly concave pedicle valve, and parvicostellate ornament of about eleven or twelve costae within 10 mm at the anterior margin (usually with intercalated, finer, alternating, third order costellae).

Comparisons. This is by far the largest orthotetacean in the Banff Formation fauna. Its large size, subquadrate outline, and weakly inflated brachial valve distinguish it from most North American species.

Schellwienella umbonata Sanders from the Represo Limestone of Sonora is similar in size and ornamentation to *S.*? cf. *S. alternata* Weller but differs from it in having a swollen, more convex dorsal umbo and more auriculate lateral extremities, producing a semiovate outline. Like *S. alternata* Weller, the description of *S. umbonata* Sanders is based on very scanty material, and is poorly known.

Schellwienella burlingtonensis Weller, also from the Burlington Limestone of the midcontinent and described from only two specimens, is similar in size and ornamentation to *S.*? cf. *S. alternata* Weller from the Banff Formation, but differs from it in having a more rounded, semiovate outline with decidedly auriculate cardinal extremities in both valves.

Remarks. The generic assignment of this species is questionable because no good pedicle valve interiors are available for study. It was decided not to disfigure the only good pedicle valve, the specimen illustrated in Plate 1. If this species lacks dental plates, it may belong to the genus *Schuchertella* Girty.

Distribution. This species may be restricted to the "upper" member of the western facies. It is common in the *Stegacanthia* cf. *S. bowsheri-Marginatia ferrglenensis* Zone at GSC localities C-57470 and C-57471. The figured specimens probably came from this zone at Sunwapta Pass, GSC locality 18527. It occurs in the *Avonia minnewankensis-Marginatia burlingtonensis* Zone at the following GSC localities: 60998, 62038, 62041, 69571, 69572, 74887, 74893 and C-57468. It also occurs at locality 74884, an unzoned horizon from the "upper" member.

One large, incomplete pedicle valve, probably of the genus *Schellwienella*, is known from the *Calvustrigis rutherfordi* Zone of the eastern facies, GSC locality 49692. The specific assignment of this specimen is uncertain, but if it should prove to belong to this species, the range of this species would be substantially lowered.

Schellwienella cf. *S. chouteauensis* Weller, 1914

Plate 1, figures 20-25

1914 *Schellwienella chouteauensis* Weller, p. 64, Pl. 7, figs. 5-8.

Description. Medium size for genus, moderately convexo-concave; outline subquadrate to subovate; slightly wider than long, greatest width at or near hinge line; body cavity moderately thin; ornament parvicostellate, consisting of numerous primary costellae, several orders of intercalated costellae that rapidly attain size of primary costellae, numbering about nine or ten per 5 mm at anterior margin; costellae and intercostal furrows with raised, closely spaced growth lines; stronger growth varices not numerous, widely and irregularly spaced.

Pedicle valve moderately concave, except for flattened umbonal region; cardinal margins straight, diverging from horizontal at moderate angle; cardinal extremities subangular; lateral margins subparallel; anterior margin rounded; beak small, twisted in one specimen but with no indication of cementation; ventral interarea strongly apsacline, low, acutely triangular, flattened; pseudodeltidium longer than wide, moderately convex; internal details not observed.

Brachial valve moderately and evenly convex in anterior profile; most convex in umbonal region but umbo not inflated, poorly defined; cardinal extremities flattened, defined by weakly concave flexures; dorsal interarea very low; chilidium very short, almost vestigial; internal details not observed.

Dimensions (mm).

GSC no.	Length	Width
10079a	32.9	34.7
10079b	+25.9	+29.6

Remarks. The above description is based on two partially silicified, nearly complete specimens from GSC locality 18293. This collection was taken high in the Banff Formation and the specimens are substantially younger than the species described below as *Schellwienella* cf. *S. bushbergensis* Branson.

Although internal information is lacking, assignment to the genus *Schellwienella* is suggested, because of the concave pedicle valve. The shell outline, with tapered cardinal margins, subparallel lateral margins, the weakly inflated brachial valve, and relatively coarse costellae, compare with *S. chouteauensis* Weller, described from the mid-Kinderhookian Chouteau Limestone of Missouri. The Banff specimens differ from Weller's types in having a more elongate outline, a more strongly apsacline ventral interarea, and other minor differences, and possibly represent an undescribed species.

Distribution. This species is known from only three localities, all from the western facies. The collection from GSC locality 69554 is from the "middle" member at the type section, Mount Rundle (*Calvustrigis rutherfordi* Zone). The other two localities are from unzoned horizons in the "upper" member: GSC locality 18293 at Mount Rundle and GSC locality 60997 at Lake Minnewanka.

Schellwienella cf. *S. bushbergensis* Branson, 1938

Plate 1, figures 17-19

1938 *Schellwienella bushbergensis* Branson, p. 162, Pl. 17, figs. 23-25.

Description. Medium size for genus, convexo-planar to dorso-biconvex, wider than long, with greatest width at hinge line in most specimens; body cavity of moderate thickness; ornament parvicostellate, consisting of numerous, fine, straight, primary costellae, several orders of intercalated costellae, and very rare bifurcations; ribs and intercostal furrows crossed by fine, regularly spaced, raised, concentric growth lines; irregularly spaced growth varices variably developed.

Pedicle valve almost flat or weakly convex; outline subquadrate to subovate; cardinal extremities subangular to slightly mucronate; beak small; ventral interarea flattened, apsacline, low, marked by faint longitudinal striae; pseudodeltidium wide, convex, with sinuous growth lines; strong, short, divergent dental plates present; other internal details not observed.

Brachial valve moderately inflated, most convex in umbonal region; cardinal extremities and umbonal region well defined by concave flexures; dorsum moderately arched in anterior profile, with lateral slopes weakly convex and sloping evenly to lateral and anterior margins; cardinal extremities subangular to angular; cardinal process low, stout, bilobed; internal details and chilidium not observed.

Dimensions (mm).

GSC no.	Valve	Length	Width
63190	Pedicle	29.5	±38.1
63191	Brachial	20.8	+31.7
63192	Brachial	21.1	28.1

Remarks. This is probably a new species of *Schellwienella*, but the collections are inadequate for a complete description and confident diagnosis of the species. As a result, it has been compared to the previously described species that most closely resembles it, namely *Schellwienella bushbergensis* Branson. Both forms possess brachial valves of comparable size and shape, a well defined inflated umbo, and fine ornament. The Banff species differs from the Bushberg species in having very few bifurcating costellae. Nearly all of the costellae arise by intercalation. Like so many Mississippian orthotetids, the Bushberg species is described from scanty incomplete material. The pedicle valve is unknown.

Schellwienella umbonata Sanders, another inadequately known species from the Represo Limestone of Sonora, also possesses the inflated dorsal umbonal region seen in the Banff species, but it differs in being much larger with coarser ornamentation.

Distribution. This species is restricted to the *Calvustrigis rutherfordi* Zone, and with one exception occurs only in the eastern facies at GSC localities 49688, 49690, 49695, 49704, 49726, C-7383 and C-11787. It occurs also in the "middle" member at Mount Rundle, GSC locality 69550.

Superfamily DERBYIACEA Stehli, 1954

Family STREPTORHYNCHIDAE Stehli, 1954

Genus *Streptorhynchus* King, 1850

Streptorhynchus sp.

Plate 1, figure 16

Remarks. Four small collections, ten specimens in all, appear to be assignable to the genus *Streptorhynchus* King. Although interior details are lacking for both valves, the rounded lateral extremities, irregular distorted surfaces, and subconical pedicle valve are characteristic of the North American species conventionally assigned to this well known genus.

The pedicle valve (Pl. 1, fig. 16) from GSC locality 49690, is the best preserved and largest specimen of this genus and the only good pedicle valve in the collections available for study. A crushed brachial valve in this collection probably belongs to the same species.

Three much smaller brachial valves, from GSC locality 49714, are also assigned to *Streptorynchus*, but may represent a distinct species.

None of these collections permits ready assignment to any previously described species.

Distribution. All of the collections were recovered from the *Calvustrigis rutherfordi* Zone. Those from GSC localities 49690, 49692, 49714 and 66038 are from the eastern facies. One specimen from the western facies, GSC locality 62101, apparently also belongs to this zone.

Suborder CHONETIDINA Muir-Wood, 1955

Superfamily CHONETACEA Bronn, 1862

Family ANOPLIIDAE Muir-Wood, 1962

Genus *Subglobosochonetes* Afanas'ieva, 1976

Subglobosochonetes norquayensis n. sp.

Plate 2, figures 1-9

Description. Medium size for family, strongly concavo-convex, usually transversely subovate in outline; maximum width attained at or near hinge line; cardinal extremities angular to subangular; ears small, defined by strong, concave flexures on pedicle valve and reflexed flattening on brachial valve; ornament of both valves consists of about fourteen to sixteen capillae per 3 mm near mid-anterior margin, fine, sinuous closely spaced growth lines, and occasional stronger irregularly spaced growth varices; capillae of pedicle valve increase by bifurcation, those of brachial valve by intercalation.

Pedicle valve strongly convex in both lateral and anterior profile, arched in anterior profile, usually most convex in umbonal region; flanks sloping evenly to anterolateral margins; ears very slightly compressed; beak inconspicuous; up to six pairs of spine bases along cardinal margin, angle of spines not determined; ventral interarea low, slightly concave, orthocline; small pseudodeltidium present at apex of delthyrium; interior details not observed.

Brachial valve strongly and evenly concave except for cardinal extremities; dorsal interarea low, hypercline; presence or absence of chilidial plates not ascertained; interior details not observed.

Dimensions (mm).

GSC no.	Length	Width	Height	Thickness
10078a	8.2	10.1	+3.6	+1.8
10078b	7.8	9.8	+3.1	+1.2
10078c	7.4	8.8	+3.0	1.6

Type material. Holotype GSC 10078a, from GSC locality 18861, Pl. 2, figs. 1-3. Paratypes 10078b and 10078c, also from GSC locality 18861, Pl. 2, figs. 4-9.

Distinguishing characteristics. This species is characterized by its modest size, strongly concavo-convex valves with arched venter, very small ears, finely capillate ornament, orthocline ventral interarea, and hypercline dorsal interarea.

Comparisons. This new species is not readily confused with other chonetids in the Banff Formation.

Chonetes miseri Girty from the Boone Formation of Arkansas is similar in size and ornament to *Subglobosochonetes norquayensis*, but differs by its subquadrate to semicircular outline and conspicuously flattened and depressed ventral umbo.

Chonetes planumbonus Meek and Worthen from the "Warsaw" shales of Monroe County, Illinois, and the New Providence Shale of Kentucky, is similar in outline and has an interarea with similar inclination, but can be readily differentiated by its large size, finer ornament, and less convex, unarched ventral umbo.

Subglobosochonetes malevkensis (Sokolskaya), the type species from the Tournaisian of the Soviet Union, differs from *S. norquayensis* in having a less inflated profile, fewer pairs of hinge spines, a semicircular outline, and a shorter ventral umbo with a correspondingly straighter cardinal margin.

Remarks. The strongly convex pedicle valve, arched venter, and modest size of this species certainly suggest anopliid affinities. Assignment of this new species to the genus *Subglobosochonetes* Afanas'ieva is, admittedly, based on external similarities.

Distribution. This species is restricted to the *Calvustrigis rutherfordi* Zone and occurs in both facies. In the eastern facies it is known from GSC localities 49690, 49695, 49704, 49706, 49734, 49741, C-4130 and C-86545. In the western facies it occurs in the collections from GSC localities 62101, 69548 and 69554.

Family RUGOSOCHONETIDAE Muir-Wood, 1962

Subfamily RUGOSOCHONETINAE Muir-Wood, 1962

Genus *Rugosochonetes* Sokolskaya, 1950

Rugosochonetes cf. *R. loganensis*
(Hall and Whitfield), 1877

Plate 2, figures 10-16

1877 *Chonetes loganensis* Hall and Whitfield, p. 253-254, Pl. 4, fig. 9.

1899 *Chonetes loganensis* Hall and Whitfield. Girty, p. 525-527, Pl. 68, figs. 5a-c.

1927 *Chonetes loganensis* Hall and Whitfield. Girty, p. 62, Pl. 22, figs. 12-15.

1962 *Nix loganensis* Hall and Whitfield. Easton, p. 46-47, Pl. 5, fig. 22.

Description. Small to medium in size for genus, moderately concavo-convex, with semicircular outline; usually substantially wider than long; cardinal extremities variably angular to rounded, greatest width variably situated from hinge line to mid-length; body cavity thin; ornament consisting of about ten to thirteen coarse capillae per 3 mm near mid-anterior margin, crossed by very fine, closely spaced growth lines; capillae increase by bifurcation on pedicle valve and intercalation on brachial valve.

Pedicle valve most convex in umbonal region or sometimes near mid-valve, sloping with very low convexity to anterolateral margins; venter slightly arched anteriorly in posterior profile; anterior half of venter depressed or flattened in a few specimens; cardinal extremities moderately compressed, delimited by weakly concave flexures; beak tiny, scarcely overhanging interarea; cardinal margins almost straight or diverging a few degrees from horizontal; six pairs of spine bases along cardinal margins, angle of inclination not determinable; ventral interarea low, slightly concave, apsacline; delthyrium wider than high; pseudodeltidium very small; internal details not observed.

Brachial valve nearly evenly and moderately concave except for cardinal extremities, which are flattened and delimited by weakly convex flexures; dorsal interarea much lower than that of opposite valve, catacline or slightly hypercline; chilidial plates not observed; small elongated node present at hinge line marking base of cardinal process; cardinal process bilobate internally, quadrilobate externally, with well developed alveolus; socket ridges short, diverging at moderate angle from hinge line; other internal details not observed.

Dimensions (mm).

GSC no.	Length	Width	Height	Thickness
63193	7.4	±10.2	2.5	1.3
63194	9.5	±11.8	3.0	1.5
63195	9.7	13.3	-	-

Distinguishing characteristics. This species can be differentiated by its moderate size, moderately concavo-convex profile, semicircular outline with rounded to angular cardinal extremities, ten to thirteen capillae per 3 mm, six pairs of spines, and nearly straight cardinal margins of the pedicle valve.

Comparisons. In the Banff Formation only *Rugosochonetes* cf. *R. multicostus* (Winchell) is similar to *R.* cf. *R. loganensis.* The former species is substantially larger, has a more elongate outline, and finer ornamentation with about eighteen capillae per 3 mm at the front margin.

Hall and Whitfield (1877, p. 254) compared their species to *Chonetes illinoisensis* Worthen, from the Burlington Limestone of the upper Mississippian Valley. They differentiated their new species by its longer hinge line and anteromedial depression or flattening of the pedicle valve. Girty (1899, p. 526), however, pointed out the inconsistent nature of these characters and concluded "In general I have been unable to discover any constant differences which might distinguish the two species."

Although there is a good deal of overlap in size, outline, and other morphological characters of these two species, I believe that they are probably distinct taxa. *Rugosochonetes loganensis* is usually more semicircular in outline with less rounded cardinal extremities. It is usually substantially thinner (lower in height), and the Canadian specimens are consistently slightly smaller than *Chonetes illinoisensis.*

Remarks. Although Girty (1899, 1927) applied this species name with confidence to specimens from the Madison Limestone of several of the western states and illustrated several additional Madison specimens, Easton (1962, p. 46, 47) recently pointed out the need for a redescription based on new topotype collections from Logan Canyon, Utah. He suggested the possibility that Hall and Whitfield's type may actually have come from the much younger, Brazer Limestone. For this reason, the Banff specimens cannot be identified with certainty and I choose only to compare them to the form described and illustrated by Girty (1899, 1927).

Distribution. This species is widely distributed in the *Calvustrigis rutherfordi* Zone of the eastern facies at GSC localities 37131, 49692, 49698, 49710, 49726, 68451 and 68567. It has also been found in this zone at GSC localities 69548 and 73521 of the western facies. It occurs in the "upper" member of the western facies at GSC locality C-57471, which is in the *Stegacanthia* cf. *S. bowsheri-Marginatia ferrglenensis* Zone.

Rugosochonetes cf. *R. multicostus* (Winchell), 1863

Plate 2, figure 17

1863 *Chonetes multicosta* Winchell, p. 5

1914 *Chonetes multicosta* Winchell. Weller, p. 79-80, Pl. 8, figs. 8-16.

1972 *Rugosochonetes* cf. *Chonetes multicosta* Winchell. Carter, p. 477, 478, Pl. 1, figs. 22-26.

Remarks. As Carter (1972, p. 477, 478) pointed out, no lectotype has been chosen from Winchell's suite of eight syntypes. Several species may be involved in the type suite. The species needs to be redescribed and a type fixed before unequivocal identifications of this species are possible.

Following Weller (1914, p. 80) and Carter (1972, p. 478), the Banff Formation specimens are compared to the best of Winchell's syntypes, a specimen from the lower Burlington Limestone (Dolbee Creek Limestone Member).

Only three Banff Formation collections are available, two from the Jasper Park area (GSC locs. 36801 and 49734). The specimen figured in Plate 2 is the best preserved pedicle valve available, but it is somewhat more elongate than the other specimens from this collection. The third collection from GSC locality 69548, consists of three specimens collected from the "middle" member at Mount Rundle. In other respects these specimens are virtually indistinguishable from lower Burlington Limestone specimens.

Distribution. All of the above mentioned collections were recovered from the *Calvustrigis rutherfordi* Zone.

Subfamily PLICOCHONETINAE Sokolskaya, 1960

Genus *Plicochonetes* Paeckelmann, 1930

Plicochonetes canadensis n. sp.

Plate 2, figures 18-24

?1899 *Chonetes ornatus* Shumard. Girty, p. 527-528, Pl. 68, figs. 4a-d.

?1927 *Chonetes logani* Norwood and Pratten. Girty, p. 62, Pl. 22, figs. 16-18.

Description. Medium size for genus, moderately concavo-convex; outline transversely subtrigonal to semicircular; greatest width attained at cardinal extremities; cardinal extremities angular to submucronate, ears small to moderately large; ornament consisting of eight to eleven, usually nine to ten, coarse capillae per 3 mm near middle of anterior margin, crossed by closely spaced, very fine, sinuous growth lines; capillae of both valves increase mainly by bifurcation, rarely by intercalation; ribbing weak or lacking on ears of both valves.

Pedicle valve moderately convex, greatest convexity near or posterior to mid-length; venter evenly convex in anterior profile; anterior half of venter may be flattened in some specimens; cardinal extremities compressed, delineated by concave flexures; umbonal region slightly swollen; lateral slopes curving evenly to antero-lateral margins; beak small, scarcely overhanging interarea; cardinal margins nearly straight, with up to three pairs of spine bases; angle of spine inclination not determined; ventral interarea apsacline, slightly concave; delthyrium wider than long, with small apical pseudodeltidium; internal details not observed.

Brachial valve moderately concave; cardinal extremities flattened, delimited by slight convex flexures; low, obscure fold usually present in anterior half of dorsum; dorsal interarea very low, hypercline; chilidial plates not observed; cardinal process quadrilobate in external view, with well developed alveolus; other internal details not observed.

Dimensions (mm).

GSC no.	Valve	Length	Width
63197	Pedicle	9.8	±16.0
63198	Pedicle	8.5	±12.8
63199	Pedicle	4.5	6.5
63200	Pedicle	9.5	17.2
63201	Brachial	9.7	+16.1
63202	Brachial	7.3	13.3
63203	Brachial	8.5	±15.6

Type material. Holotype GSC 63200, a pedicle valve, from GSC locality C-86544, Pl. 2, fig. 19. Figured paratypes GSC 63197-63199, 63201-63203, three pedicle valves and three brachial valves, all from GSC locality C-86544, Pl. 2, figs. 18, 20-24. Unfigured paratypes GSC 63204 to 63206, two complete specimens in matrix, one pedicle valve, and one spalled brachial valve, all from GSC locality C-86544.

Distinguishing characteristics. This species can be differentiated from similar taxa by its moderate size, transverse subtrigonal to semicircular outline, angular to submucronate ears, about nine to ten coarse capillae per 3 mm near the anterior margin, capillae that usually increase by bifurcation on the brachial valve, and a weak obscure fold on the brachial valve.

Comparisons. Plicochonetes canadensis n. sp. is most similar and possibly related to *Plicochonetes ornatus* (Shumard) from the Upper Devonian Louisiana Limestone of Missouri. *Plicochonetes ornatus* differs in having smaller ears, a more subquadrate outline, coarser ribbing (seven to eight per 3 mm), and dorsal ribs that are formed mainly by intercalation.

Caenanoplia logani (Norwood and Pratten), a common species in the Hampton Formation of Iowa and the Chouteau Limestone of Missouri, is externally similar to some of the less transverse or auriculate specimens of *Plicochonetes canadensis* n. sp. However, the midcontinental species is easily distinguished by its much weaker, almost obsolete, finer ribbing, much more inflated profile, smaller ears, and orthocline ventral interarea.

Chonetes ornatus var. *arkansanus* Girty, from the Boone Limestone of Arkansas, is based on a very tiny pedicle valve. Girty (1915a, p. 11) described the type as being a strongly convex mature specimen despite its minute size. It is roughly similar in outline and ornamentation to the several species discussed above, but its affinities are impossible to ascertain.

Remarks. Girty (1899) described and illustrated specimens of a species, probably belonging to the genus *Plicochonetes* Paeckelmann, which he assigned to *Chonetes ornatus* Shumard. Later (Girty, 1927), he reassigned these specimens to *Chonetes logani* Norwood and Pratten. The most readily determinable characters of these specimens are comparable to those of *Plicochonetes canadensis* n. sp.

Plicochonetes aff. *Chonetes ornatus* Shumard of Carter (1967, p. 280-281, Pl. 13, figs. 8a-13), from the Chappel Limestone of central Texas, is another species of *Plicochonetes* possibly conspecific with *P. canadensis* n. sp. Unfortunately, the Texas material is too poorly preserved for accurate identification.

Distribution. The description of this species is based on two collections from the Canyon Creek Section, Alberta, GSC localities 66332 and C-86544. Both collections are from the *Calvustrigis rutherfordi* Zone.

Suborder PRODUCTIDINA Waagen, 1883

Superfamily PRODUCTACEA Gray, 1840

Family LEIOPRODUCTIDAE Muir-Wood and Cooper, 1960

Subfamily LEIOPRODUCTINAE Muir-Wood and Cooper, 1960

Genus *Spinocarinifera* Roberts, 1971

Subgenus *Seminucella* n. subgen.

Plate 3, figures 1-20

Type species. Spinocarinifera (*Seminucella*) *parva* n. subgenus, n. sp., from the Banff Formation of Alberta.

Diagnosis. Small, geniculate Leioproductinae with weakly rugose ventral visceral disc bearing low, elongate spine base ridges; ventral trail costellate with costellae bearing spine bases; brachial valve ornament similar but with elongate dimples instead of spine ridges on visceral disc, spine seemingly lacking; small median tubercle at hinge line; dorsal interior with large alveolus; cardinal process bilobed in all growth stages; lateral ridges extending along hinge line to lateral extremities.

Description. Smaller than average for genus, strongly concavo-convex, slightly longer than wide or about equidimensional; greatest width usually attained near mid-length; outline subovate to subquadrate; outline of visceral disc semisubovate to subquadrate; ears small, well defined, subangular; both valves geniculate, brachial valve much more geniculate than pedicle valve, forming moderately thick body cavity; trails short to moderate in length; shell substance thin.

Pedicle valve strongly inflated, almost evenly convex to strongly geniculate in profile; venter weakly convex to evenly rounded, never with sulcus; flanks less convex than venter; ears delimited by concave flexures; anterior profile semi-ovate to subquadrate; umbo moderately broad with umbonal angle of about 90 degrees; beak small, projecting very little beyond hinge line; ornament of weak, irregularly spaced rugae and scattered, elongate, low, spine base ridges on visceral disc, with spine ridges producing irregular to well developed costellae on trail; fine spines scattered on costellae, more numerous on ears, lateral extremities, and along hinge line; internal details unknown.

Brachial valve with flattened, weakly convex visceral disc and strongly geniculate trail; ears delimited by weakly convex flexures; median tubercle produced at hinge line, reflecting dorsal fusion of cardinal process; ornament of weak, irregularly spaced rugae and scattered dimples on visceral disc with irregular to well developed costellae on trail; spines seemingly lacking; cardinal process small, sessile, bilobed in large adults, lobes fused only at dorsal extremities; alveolus well developed; lateral ridges extending along hinge line to lateral extremities; breviseptum thin, extending from near alveolus forward about half or two-thirds the length of visceral disc; brachial ridges diverge at high angle from hinge line; adductor scars small, non-dendritic, guttate.

Other species assigned to the subgenus. Avonia pustulifera Moore, from the Lower Burlington white chert of Missouri, is clearly closely related to *Spinocarinifera* (*Seminucella*) *parva* n. sp. and certainly belongs to this new subgenus. Pedicle valve exteriors and brachial valve interiors of the latter are illustrated in Plate 3 in order to establish the subgenus more firmly.

Productus rushvillensis Herrick, from the Logan Formation of Ohio, is externally similar to the species described above. Brachial valve interiors are not known and assignment to this genus is not certain.

Productella semicostata Girty, from the lower Boone Formation of Arkansas, is also externally very close to authentic *Seminucella* species. Brachial valve interiors are again unknown. Hyde (1953, p. 234) considered this species to be a junior synonym of *Productus rushvillensis* Herrick.

Discussion. The species cited above seemingly form a closely related, distinct group of species that can be readily distinguished from more typical *Spinocarinifera* by their smaller size, bilobed cardinal process in adult shells, well developed alveolus, and by having costellae only on the trail, not on the visceral disc.

The larger *Spinocarinifera* of the *S. adunata* Roberts, *S. arcuata* (Hall) and *S. niger* (Gosselet) type have a trilobed cardinal process with a peg-like median lobe in adult shells. In addition, they have a weak alveolus, or more commonly, none at all, and the costae of the pedicle valve originate in the umbonal region well onto the visceral disc.

The species assigned to the new subgenus *Seminucella* thus seem to constitute a distinct and supra-specific taxon. The close similarity of this group of species to *Spinocarinifera adunata* Roberts, however, suggests that *Seminucella* does not justify full generic status in view of our present understanding of productid genera.

Derivation of name. Latin *semi*, half; Latin *nucella*, small nut or kernel, referring to the shape of the pedicle valve.

Stratigraphic range. Middle to upper Tournaisian (upper Kinderhookian to middle Osagean).

Spinocarinifera (*Seminucella*) *parva* n. sp.

Plate 3, figures 1-20

Description. Small for family, concavo-convex, longer than wide, greatest width attained near mid-length; outline subovate to subquadrate; outline of visceral region subquadrate; lateral profile variable from subquadrate to semisubovate; ears small, well defined, subangular; both valves geniculate; trail short to moderate; body cavity moderately thick; shell substance thin.

Pedicle valve strongly inflated, most convex in umbonal region and at point of geniculation; remainder of visceral disc only slightly less convex; trail less convex and almost evenly rounded; flanks flattened, subparallel; ears delineated by small concave flexures; lateral extremities vertical and flange-like; venter flattened or gently rounded but sulcus never produced; anterior profile subquadrate; umbo moderately broad, usually producing umbonal angle of about 90 degrees; beak very small, slightly overhanging hinge line; ornament consisting of weak, irregular rugae and weak, low, scattered, elongate spine base ridges on visceral disc, and low, rounded, more or less regular costellae on trail, about five or six per 3 mm on venter; costellae of variable strength and regularity, sometimes merging or becoming obsolete before reaching anterior margin; scattered spines on visceral disc fine and probably prostrate; spines on trail scattered on crests of costellae; several rows of fine spines extend along hinge line and around sides of umbo and ears, forming small, laterally directed brush on posterolateral extremities; growth lines fine, sinuous, irregular in width; internal details not observed.

Brachial valve strongly geniculate, with weakly concave visceral disc, strongly concave flexure at point of geniculation, and moderately and evenly concave short trail; ears set off by weak convex flexures; small rounded or elongate node marking dorsal fusion of lobes of cardinal process formed at middle of hinge line; ornament consisting of weak, irregular rugae and elongate, radially aligned dimples on visceral disc, but rounded and more numerous on ears, with crests between dimples becoming regular costellae near point of geniculation and on trail; growth lines as on pedicle valve; spines or spine bases not observed; cardinal process small, sessile, bilobed, supported by two very short, stout buttress plates, which form large rounded antron; brevi-septum very slender, extending forward much of length of visceral disc; lateral ridges extend along hinge line to ears not diverging appreciably; adductor scars small, non-dendritic, guttate, posterior pair very small; other details not observed.

Dimensions (mm).

GSC no.	Length	Width	Height	Surface measurement
63207	10.9	10.0	8.1	21.2
63208	10.9	9.3	7.1	20.5
63209	10.2	8.9	6.3	18.0
63210	9.6	8.4	6.3	18.4

Type material. Holotype GSC 63207, from GSC locality 49707, Pl. 3, figs. 1-4. Paratypes GSC 63208-63210, GSC locality 49707, Pl. 3, figs. 5-20.

Distinguishing characteristics. This species is characterized by its small size, geniculate valves, flattened venter, subquadrate anterior profile, and its ornament, consisting of weak rugae and weak spine ridges on the visceral disc, with well developed, rounded costellae on the trail and with fine spines set on the costellae and in rows at the hinge line, wrapping around the ears. In addition, the cardinal process is supported by short stout buttress plates with a large, rounded antron.

Comparisons. There are few previously described species that are similar to this new species in both external and internal details. *Avonia pustulifera* Moore, from the lower Burlington Limestone of Missouri, is similar in most respects to *Spinocarinifera* (*Seminucella*) *parva* n. sp., but differs in being larger, with a more rounded venter in anterior profile, and in having a shorter trail, and fewer coarser costae on the trail.

Avonia minima (Tolmachoff) from the Tournaisian of the Kuznets Basin is somewhat similar externally, but lacks the distinctive cardinalia of this new Banff species. Externally it also differs in having an evenly rounded and lower anterior profile, weaker costellae on the trail, and stronger spine ridges on the visceral disc. *Avonia semicostata* (Tolmachoff), also from the Tournaisian of the Kuznets Basin, is similar in size and lateral profile to the Banff species, but differs by its very convex venter and much stronger ribbing on the trail. Internal details of *A. semicostata* are not known.

Productus rushvillensis Herrick, from the Logan Formation of Ohio, and *Productella semicostata* Girty, from the lower Boone Formation of Arkansas, are similar to *Spinocarinifera* (*Seminucella*) *parva* in size, lateral profile, and ornament, but differ by their coarser ribbing, shorter trails, more transverse outline, and less inflated umbonal regions.

Interiors are not known for these two very similar and possibly conspecific forms.

Distribution. This species seems to be restricted to the *Calvustrigis rutherfordi* Zone of the eastern facies. It is common in the Jasper region at GSC localities 49690, 49706, 49707, 49723, 49735, 49740, 49753 and 49756. It also occurs at GSC locality 68524.

Spinocarinifera (*Spinocarinifera*) *copiosa* n. sp.

Plate 4, figures 1-26; Plate 12, figures 16, 17

Description. Average size for subgenus, concavo-convex, longer than wide, greatest width attained anteriorly; ventral outline elongate subovate to subtrapezoidal; outline of visceral disc subquadrate to semisubovate; lateral profile

semicordate to semisubovate; ears very small, subangular, slightly compressed in some specimens; pedicle valve moderately to weakly geniculate, brachial valve strongly geniculate; trail moderate to long; body cavity moderately thick; shell substance thin.

Pedicle valve strongly inflated in umbonal region, flanks sloping steeply to lateral margins and usually spreading slightly; ears defined by small, concave flexures posteriorly, and sometimes further delimited by shallow, concave depressions on lateral extremities just anterior to ears; venter commonly flattened, or less commonly rounded, often producing a subquadrate to subtrapezoidal anterior profile; sulcus lacking or very weak; umbonal region characteristically projecting posteriorly well beyond hinge line; umbonal angle moderately broad, usually in excess of 90 degrees; beak small, overhanging hinge line slightly; ornament consisting of weak irregular rugae, strongest on ears, and scattered low elongate spine base ridges on umbonal region, forming faint costae on remainder of visceral disc, and well developed costae on trail, which may become obsolete near anterior margin in some large adults; number of costae highly variable, ranging from four to eight per 5 mm on trail; sparse row of fine spines at hinge line projecting posteriorly; one or more rows of four to six spines originating at sides of beak extending around ears to lateral extremities; spines scattered on costae of venter and flanks or sometimes forming crudely concentric rows, which tend to form brush at sides of lateral extremities; growth lines closely spaced, sinuous; adductor scars in adults raised on low platform, elongate-ovate, separated posteriorly by low, rounded median ridge; diductor scars in large adults flabellate, deeply grooved, impressed, not extending forward beyond adductors.

Brachial valve with moderately concave visceral disc; ears delimited by low, convex flexures; very small, rounded node formed at middle of hinge line; trail moderately to strongly geniculate; ornament consisting of weak, irregularly spaced rugae and elongate dimples on visceral disc, and well developed costae on trail, which sometimes extend well onto visceral disc; spines not observed; cardinal process short, sessile, bilobed internally, trilobed externally with peg-like median lobe, supported by broad base of median septum that extends forward about three fourths of visceral disc, becoming high and blade-like anteriorly; lateral ridges diverging very little from hinge line, curving around lateral extremities; brachial ridges diverging at low to moderate angle from hinge line; adductor scars guttate, impressed between broad, low callosities of posterior platform.

Dimensions (mm).

GSC no.	Length	Width	Height	Surface measurement
63215	21.5	17.9	11.6	39.5
63216	21.2	17.3	13.3	40.9
63217	17.5	16.6	13.0	32.3
63218	16.2	15.5	11.2	+37.0
63219	17.9	±16.4	12.2	30.0
63220	16.2	15.3	12.1	31.0

Type material. Holotype GSC 63216, from GSC locality C-7388 (a pedicle valve), Pl. 4, figs. 5-8. Paratypes GSC 63215, from GSC locality 49692 (a pedicle valve), Pl. 4, figs. 1-4; GSC 63217, from GSC locality C-4129 (a pedicle valve), Pl. 4, figs. 9-12; GSC 63218, from GSC locality C-7388 (a pedicle valve), Pl 4, figs. 13-16; GSC 63219, from GSC locality 49707 (a pedicle valve), Pl. 4, figs. 17-20; GSC 63220, from GSC locality C-7388 (both valves), Pl. 4, figs. 21-25; GSC 63221, from GSC locality 49707 (both valves) Pl. 4, fig. 26; GSC 63222, from GSC locality C-7388 (a brachial valve), Pl. 12, figs. 16, 17.

Distinguishing characteristics. This species is characterized externally by its subquadrate anterior profile, very small ears, narrow hinge line, flattened venter on many large specimens, moderately long trail, one or more rows of spines extending along the sides of the umbo around the ears to the sides of the lateral extremities, and, usually, several erect spines or even a brush on the sides of the lateral extremities. Internally, the cardinal process is trilobed in dorsal view with a peg-like median lobe, the lateral ridges wrap around the cardinal extremities, and the brachial ridges are given off at a low angle to the hinge line.

Comparisons. The only North American species similar to *Spinocarinifera* (*Spinocarinifera*) *copiosa* n. sp. is *Productus parviformis* Girty from the Madison Limestone of Yellowstone National Park. This species resembles *S.* (*S.*) *copiosa* in shape, number of costae, and general aspect, but differs from it in having much deeper coarser umbonal rugae, coarser spines on the trail and lateral extremities, and less numerous spines. The costellae are more uniform in width and more regularly disposed and the ears on the brachial valve syntype (USNM 35167) are very large and unusually extended. In addition, *Productus parviformis* may be smaller than the Banff species but to the author's knowledge, substantial comparative collections are not available.

Spinocarinifera (*Spinocarinifera*) *copisoa* n. sp. is also similar to *S. adunata* Roberts, the type species for the genus from the Tournaisian of Australia, *S. inflata* (Sokolskaya) from the Tournaisian of the Soviet Union, and *S. niger* (Gosselet) from the Etroeungtian and Tournaisian of Europe.

Spinocarinifera adunata Roberts differs externally by its transverse outline, larger ears, wider hinge line, and shorter trail. Internally, it has weaker lateral ridges that do not curve around the ears appreciably, and it possesses a shallow alveolus.

Spinocarinifera inflata (Sokolskaya) differs from this new Banff species in having a much more rounded anterior profile, and in apparently lacking a row of spines curving from the sides of the umbo around the ears with a brush of spines at the sides of the lateral extremities. Internally, the brachial ridges are given off at a high angle to the hinge line and a weak alveolus may be present.

Productus niger Gosselet, 1888, was chosen by Nalivkin (1975, p. 160) as the type species of a new genus *Nigeroplica*, although Roberts (1971, p. 101) assigned it to his genus *Spinocarinifera*. Interiors of *Productus niger* have not been described, so final generic assignment is uncertain. It differs externally from *S.* (*S.*) *copiosa* n. sp. by its larger size, more transverse outline, shorter trail, and in commonly having a shallow median sulcus, a very rare feature in the Banff species.

Distribution. This species is restricted to the *Calvustrigis rutherfordi* Zone, although a closely related subspecies occurs in the basal beds of the Shunda Formation. *Spinocarinifera copiosa* n. sp. is very common in the eastern facies, occurring at many known localities, including GSC localities 31347, 36777, 49692, 49695, 49704, 49705, 49706, 49707, 49723, 49728, 49735, 49736, 49740, 49744, 66038, 68445, 74860, 74861, C-4129, C-4130, C-7383, C-7388, C-86543, C-86544 and C-86545. In the western facies it is known only from the "middle" member at the type section, Mount Rundle, GSC locality 69552.

Spinocarinifera (Spinocarinifera) arcuata (Hall), 1858

Plate 11, figures 1-4

1858 *Productus arcuatus* Hall, p. 18, Pl. 7, fig. 4a, b.

Remarks. This well known Kinderhookian species from the midcontinental region has been reported from the Banff Formation by several authors, including Shimer (1926, p. 4), Brown (1952, p. 87), Harker and Raasch (1958, p. 226), Harker and McLaren (1958, p. 252), and Nelson (1961, Pl. 5, figs. 14-16).

I have found only one pedicle valve in the GSC collections that can be assigned to this species with confidence. This specimen, from GSC locality C-4130 (*Calvustrigis rutherfordi* Zone), is similar in most respects to typical specimens from the Wassonville Dolomite of Burlington, Iowa, and the Chouteau Limestone of Missouri, although it has a few more umbonal rugae than is usually found in the Iowa and Missouri specimens. Nevertheless, it falls well within the range of variability of authentic specimens in this respect.

Family OVERTONIIDAE Muir-Wood and Cooper, 1960

Subfamily OVERTONIINAE Muir-Wood and Cooper, 1960

Genus *Rugauris* Muir-Wood and Cooper, 1960

Rugauris robusta n. sp.

Plate 5, figures 18-34

Description. Average size for genus, pedicle valve moderately to strongly convex; length and width about equal, greatest width usually near mid-length; outline subcircular to subovate, rarely subquadrate; visceral region flattened in both valves, with subquadrate outline; lateral profile subtriangular; ears small, subangular, moderately to poorly delimited, slightly compressed; both valves geniculate; long trail produced in pedicle valve, dorsal trail short; body cavity moderately thick.

Pedicle valve most convex where visceral disc and trail are joined, much less convex on disc and trail, sloping fairly steeply to lateral margins, with ears delimited by concave flexures; venter evenly convex, anterior profile semicircular to subsemiovate; beak small; visceral disc ornamented with numerous, closely spaced, narrow, slightly irregular, concentric rugae and a few longitudinal spine ridges that terminate anteriorly in small prostrate spine bases; flanks and trail ornamented with several weak, low, irregular, flexuous rugae and numerous low, indistinct, longitudinal spine ridges that can either originate or terminate in fine spine bases; two rows of fine spines on hinge line wrap around ears, and two to five concentric rows of closely spaced, fine, semierect spines extend around anterior and lateral margins; entire surface covered with conspicuous, sinuous growth lines; interior details unknown.

Brachial valve with flattened to moderately concave visceral disc well delimited by geniculation forming short evenly concave trail; ears delimited by weakly convex flexures; ornament of visceral disc consisting of numerous narrow, closely spaced rugae similar to pedicle valve, and scattered pits or depressions that complement spine ridges of pedicle valve; trail with numerous shallow, elongate depressions; spine bases apparently lacking; surface covered with distinctive growth lines similar to those of pedicle valve.

Brachial valve interior with small sessile cardinal process, bilobed in internal view; median septum extending forward about two thirds the length of visceral disc as low, narrow blade, forming broad, low support for cardinal process posteriorly; lateral ridges diverging slightly from hinge line, not reaching ears; brachial ridges given off at low angle; adductor scars obscurely defined in available specimens; numerous endospines on trail.

Dimensions (mm).

GSC no.	Length	Width	Height	Thickness	Surface measurement
63224	33.1	31.1	19.0	13.8	53.0
63225	28.6	31.5	15.0	11.2	43.8
63226	28.6	29.3	13.7	±10.6	45.0

Type material. Holotype GSC 63224, from GSC locality 36777, Pl. 5, figs. 20-24. Paratypes GSC 63225, 63226, from GSC locality 36777, Pl. 5, figs. 25-34.

Distinguishing characteristics. This species is characterized by its inflated pedicle valve, thick body cavity, and two or more rows of spines that originate near the hinge line and wrap around the ears.

Comparisons. Other described species of this genus are *Rugauris paucispina* Muir-Wood and Cooper from the Lower Mississippian Chapin Limestone (=Starr's Cave Oolite) of central Iowa; *Rugauris curtirostra* (Winchell) from the upper Famennian or lower Kinderhookian English River Sandstone of southeastern Iowa; and *R. inica* (Sarycheva) from the lower Tournaisian of the Kuznets Basin of southwestern Siberia.

Rugauris paucispina differs from *R. robusta* n. sp. by its low thin pedicle valve, thinner body cavity, single row of spines at the hinge line, and fewer spines on the trail. *Rugauris curtirostra* has much stronger spine ridges, especially on the trail, than *R. robusta.* In addition, *R. curtirostra* has a thinner body cavity, and it usually has smaller, less well delimited ears. *Rugauris inica* is much larger than *R. robusta,* with a relatively longer trail, stronger spine ridges on the pedicle valve trail, and much more conspicuous longitudinal grooves on the brachial valve visceral disc than *R. robusta.*

Distribution. Rugauris robusta n. sp. is known only from the *Calvustrigis rutherfordi* Zone of the eastern facies, GSC localities 31349, 36777, 68487, C-86543 and C-86545.

Genus *Semiproductus* Bublichenko, 1956

Semiproductus calhounensis (Moore), 1928

Plate 8, figures 20-23

1928 *Productus calhounensis* Moore, p. 266-267, Pl. 10, figs. 1-6.

1938 *Productus calhounensis* Moore. Branson, p. 31-32, Pl. 2, figs. 1-3.

1948 *Plicatifera* aff. *P. calhounensis* (Moore). Cloud and Barnes, Pl. 44, fig. 26 (not figs. 22, 23).

1967 *Rhytiophora calhounensis* (Moore). Carter, p. 294-297, Pl. 21, figs. 1a-11.

Remarks. There are two specimens in the collections at hand that may be assigned to this well known species, one with considerable confidence, the other with less confidence. The former specimen, from near the top of the Banff Formation of the Jasper Park region (GSC locality 49719) was collected by R.A.C. Brown in 1944. Several views of the nearly complete pedicle valve are illustrated in Plate 8, figures 20-23. The brachial valve is fragmentary and widely gaping and no diagnostic internal features are preserved. The pedicle valve is similar in almost all respects to authentic specimens of *Semiproductus calhounensis* from the Chouteau Limestone of Missouri. The other specimen, a small, nearly complete visceral disc from the "upper" Banff at Cripple Creek, Alberta, was collected by Erdman in 1949, and is assigned here with reservation. It is not illustrated here. This specimen resembles *S. calhounensis* in all characters except one. It has a thin body cavity and does not appear to be crushed. *Semiproductus calhounensis* has a thick body cavity. Direct comparison with a small visceral disc from the Chappel Limestone of Texas shows that the Banff specimen is significantly thinner than one would expect for *S. calhounensis.*

Genus *Avonia* Thomas, 1914

Avonia banffensis n. sp.

Plate 6, figures 25-33; Plate 7, figures 37-43

Description. Smaller than average for genus, strongly concavo-convex, longer than wide, greatest width slightly anterior to mid-length; outline subovate; lateral profile semisubovate; ears small, well defined, moderately compressed; pedicle valve not geniculate, brachial valve slightly geniculate; trails of moderate length; body cavity thin, average for genus; shell substance thin.

Pedicle valve strongly and nearly evenly convex in lateral profile; venter evenly rounded or slightly flattened in some specimens, flanks much less convex and sloping steeply to lateral margins, ears delimited by concave flexures; anterior profile semisubovate to subquadrate; beak small, slightly overhanging hinge line; umbo moderately narrow; ornament consisting of weak, irregular rugae, which are strongest on ears; scattered, small elongate spine base ridges that rarely form low, faint, short, irregular costellae on anterior two thirds of valve; very fine, probably prostrate spines scattered to quincuncially arranged on umbonal region; scattered to concentrically arranged rows of fine, suberect spines on trail, and a few, scattered, erect spines on ears and lateral extremities; growth lines very fine, sinuous. Interior details not observed.

Brachial valve strongly concave, slightly less concave posteriorly forming poorly delimited visceral disc, most convex anteriorly, slightly geniculated with less concave trail; small ears set off by low convex flexures; small rounded tubercle formed at midpoint of hinge line reflecting point where cardinal process lobes fuse; ornament consisting of numerous low, narrow, irregular, sinuous rugae and scattered to quincuncially arranged, small, rounded dimples on visceral disc; trail lacking rugae, dimples elongated; ears with smaller, more numerous dimples; spines not observed; growth lines as in pedicle valve; internal details not observed.

Dimensions (mm).

GSC no.	Length	Width	Height	Surface measurement
63230	8.0	6.8	5.3	14.0
63231	9.4	7.6	7.5	15.8
63232	8.6	6.7	5.1	13.8
63233	9.1	8.8	6.2	-

Type material. Holotype GSC 63231, a nearly complete specimen, from GSC locality C-86542, Pl. 6, figs. 29-33. Paratypes: GSC 63230, a pedicle valve, from GSC locality C-4130, Pl. 6, figs. 25-28; GSC 63232, a pedicle valve, from GSC locality C-4130, Pl. 7, figs. 37-40; GSC 63233, a natural mould of a brachial valve exterior, from GSC locality C-86542, Pl. 7, figs. 41-43.

Distinguishing characteristics. This species can be differentiated by the small rugae, elongate spine base ridges, lack of costellate ornament on the pedicle valve, and presence of rugae and rounded dimples on the brachial valve.

Comparisons. In the Banff Formation, *Avonia banffensis* n. sp. is similar only to *Avonia canyonensis* n. sp. The latter can be distinguished by its larger size, weakly costellate ornament on the pedicle valve, rows of spines that originate under the ventral beak and wrap around the ears, and lateral extremities forming laterally directed spine brushes.

Pustula laevicula Moore from the Sedalia Limestone and lower Burlington Limestone of Missouri is similar in size and general configuration to *A. banffensis* n. sp., but differs in its apparent complete lack of elongate spine base ridges and rugose ornament. The brachial valve of *Pustula laevicula* has not been described.

Avonia newarkensis Moore from the Chouteau Limestone of Missouri is perhaps the species most similar to *A. banffensis* n. sp. that has previously been described. *Avonia newarkensis* is readily differentiated by its substantially larger size, broader outline in most specimens, and lower anterior profile with more evenly rounded lateral slopes. The ornamentation of both pedicle and brachial valves of these species is very similar.

Distribution. Avonia banffensis n. sp. is moderately common in the *Calvustrigis rutherfordi* Zone of the eastern facies, occurring at GSC localities 49688, 49706, 49707, 49709, C-4130, C-86542, C-86544 and C-86545. It also occurs at one locality in the western facies, GSC locality C-57469, which is in the *Stegacanthia* cf. *S. bowsheri-Marginatia ferneglenensis* Zone.

Avonia canyonensis n. sp.

Plate 6, figures 19-24

Description. Medium size for genus, strongly inflated, longer than wide, greatest width anterior to mid-length; outline elongate subovate; lateral profile semisubovate; ears small but well delimited, subangular, compressed; pedicle valve not geniculate; trail of moderate length for genus; shell substance very thin.

Pedicle valve strongly convex, most convex umbonally; venter strongly convex; lateral slopes weakly convex, sloping steeply to lateral margins; anterior profile semisubovate; ears formed by concave flexures; umbonal region narrow, forming an umbonal angle of about 60 degrees or less; beak

small, slightly overhanging hinge line; ornament consisting of weak elongate spine ridges over most of valve, except ears, lateral extremities, and anterior margins; spine ridges forming low, weak, rounded, irregular costellae on venter, lateral slopes, and trail; entire surface weakly and irregularly rugose with rugae strongest on ears; spines small, probably prostrate on umbo, probably suberect on venter and trail, moderately erect on ears and cardinal extremities; spines sparse over most of valve, roughly quincuncially arranged on umbo, sometimes in crude, concentric rows anterior to umbo; several rows of spines originate on sides of beak near hinge line, extend forward on side of umbo and wrap around ears to cardinal extremities, forming moderately dense brush of erect spines; growth lines fine, sinuous, almost regularly spaced; interiors not observed.

Brachial valve unknown.

Dimensions (mm).

GSC no.	Length	Width	Height	Surface measurement
63234	12.4	9.9	8.0	22.5

Type material. Holotype GSC 63234, Pl. 6, figs. 19-22, from GSC locality C-86543. Paratype GSC 63235, Pl. 6, figs. 23, 24, from GSC locality C-86543.

Distinguishing characteristics. This species can be distinguished by its moderate size, elongate umbonal region, elongate spine ridges over most of pedicle valve, weak costellae, and rows of spines that originate at beak, wrap around ears and form brushes on cardinal extremities.

Comparisons. Avonia canyonensis n. sp. is not very similar to most previously described species of the genus *Avonia*. It can be readily distinguished from most avoniids in the Banff Formation by its very weak costellate ornament. In this respect it resembles *Avonia banffensis* n. sp., also found in the Banff Formation from a horizon slightly below that from which *A. canyonensis* was recovered. *Avonia banffensis* is similar in some respects, such as having low, scattered, elongate spine bases, but it never has true costellae, is smaller, and lacks the rows of spines that originate under the ventral beak and wrap around the ears.

Distribution. This rare species occurs at only two localities in the *Calvustrigis rutherfordi* Zone, GSC localities 49688 and C-86543.

Avonia minnewankensis (Shimer), 1926

Plate 6, figures 1-14

1926 *Productus minnewankensis* Shimer, p. 40-41, Pl. 1, figs. 6a-c, 7.

1942 *Avonia linospinosa* Sutton, p. 466, Pl. 71, figs. 5-7.

1942 *Avonia minuta* Sutton, p. 466-467, Pl. 71, figs. 3, 4.

1961 *Linoproductus? minnewankensis* (Shimer). Nelson, Pl. 9, figs. 4, 5.

Description. Medium size for genus, strongly concavo-convex, longer than wide, greatest width anterior to mid-length; outline elongate subovate; lateral profile almost evenly and strongly convex, subsemiovate; ears small but well produced, angular, compressed; neither valve geniculate; body cavity of moderate thickness, trails moderately short; shell substance of both valves thin.

Pedicle valve strongly convex, most convex in umbonal region; venter strongly and evenly convex; lateral slopes less convex, sloping steeply to lateral margins; ears formed by concave flexures; anterior profile subovate to semiovate; umbonal region narrow to moderate, umbonal angle about 58-68 degrees; beak small, slightly overhanging hinge line; ornament consisting of fine, scattered, rounded spine bases and very weak rugae on umbo, spine bases occasionally forming very weak, indistinct, elongate spine ridges or, more commonly, faint costellae that gradually become strong, rounded costellae in anterior two thirds or more of shell, with about six to seven per 3 mm on trail of large specimens; interspaces between costellae rounded, almost as wide as costellae; costellae increase most commonly by intercalation posteriorly and by bifurcation anteriorly; spines scattered on nearly smooth umbonal region, forming irregular concentric rows on costellae anteriorly; concentric rows commonly forming moderate concentration of erect spines over ears and at lateral extremities; strong, sublamellar growth varices formed on trail; fine, closely spaced, regular growth lines found on entire valve; interior details not observed.

Brachial valve strongly and evenly concave except for reflexed areas around ears; trail short; posterior portion of dorsum between ears forming narrow depression complementary to umbo of pedicle valve; small, rounded, slightly elongate tubercle formed at medial edge of hinge line reflecting dorsal point of fusion with cardinal process lobes; ornamentation consisting of well developed costellae anteriorly, becoming fainter posteriorly, or forming very low, weak, indistinct, elongate nodes or tubercles in posterior third of valve, costellae increase anteriorly by bifurcation; entire surface of natural moulds weakly and irregularly rugose probably reflecting lamellose or sublamellose growth lamellae; growth line as on pedicle valve; few, small, rounded dimples on ears; spine bases very fine, scattered, situated on costellae anteriorly, sometimes crudely arranged in concentric rows; interior with small, sessile, bilobed, cardinal process with lobes fused dorsally; cardinal process slightly buttressed by low, medially depressed thickening near hinge line; short breviseptum originating between muscle scars extending forward only about one quarter of length of valve; lateral ridges well developed, diverging only slightly from hinge line, forming prominent rim around ears and extending forward to about mid-valve; brachial ridges indistinct on Banff specimens but elongate lobate and diverging at high angle from hinge line on Burlington Limestone specimens; radially aligned and crudely quincuncially arranged, elongate, small endospines over most of valve surface; adductor scars not observed on Banff specimens, elongate, trigonal, small, moderately raised, smooth, not differentiated into anterior and posterior pairs in Burlington specimens.

Dimensions (mm).

GSC no.	Length	Width	Height	Surface measurement
4551	11.5	8.4	±7.0	20.0
4551a	10.3	9.0	7.5	19.5
63236	11.9	9.1	6.4	20.2

Type material. Holotype GSC 4551, Pl. 6, figs. 1-4. Paratype 4551a, Pl. 6, figs. 5-8, both from Shimer's section 2, bed 25. Figured Banff specimens GSC 63236 and 63237, from GSC locality 69571, Pigeon Mountain Section, Pl. 6, figs. 9-14.

Distinguishing characteristics. This little *Avonia* is characterized by its moderate size, highly inflated pedicle valve with strongly convex venter and well developed costellae on both valves.

Comparisons. *Avonia minnewankensis* (Shimer) is not very similar to most of the Banff Formation avoniids. The form described here as *Avonia* sp. (Pl. 6, figs. 15-18) is similar in some respects but is much larger, with a flattened venter, and coarser ribbing.

Avonia batchatica (Tolmachoff) from the Tournaisian of the Kuznets Basin of the Soviet Union, is very similar to *A. minnewankensis* in size and many external characters, but it can be differentiated by its ventral umbonal ornament of well developed elongate tubercles and the lack of well developed radial ornament on the brachial valve.

Avonia williamsana Girty, from the upper Boone Formation (Keokuk age) of Missouri, is much larger, much more transverse with a shorter trail, and has better developed umbonal spine ridges than *A. minnewankensis.*

Remarks. Sutton (1942, p. 466) proposed two species of *Avonia*, *A. linospinosa* and *A. minuta*, without comparison with *A. minnewankensis.* I have examined Sutton's types in the University of Illinois collections and the large, non-type collection of *A. linospinosa* in the Rowley Collection, also at the University of Illinois, and believe that *A. linospinosa* Sutton is a subjective junior synonym of *A. minnewankensis* (Shimer). Sutton's species *A. minuta* is a natural mould of a brachial valve exterior of *A. linospinosa.* It possesses the distinctive, small depression at the medial edge of the hinge line that reflects the dorsal fusion of the lobes of the bilobed cardinal process so characteristic of many avoniids, and there can be no doubt that it is a brachial valve. Furthermore, ornamentation shape and size are identical to brachial valves of *A. linospinosa*, the only other *Avonia* known from the Burlington Limestone.

Sarycheva (1963, p. 143) placed *A. linospinosa* Sutton in synonymy with *Avonia batchatica* (Tolmachoff), but as pointed out above, the two appear to be similar but distinct species.

Distribution. This species is one of the name-givers for the uppermost zone of the Banff Formation, the *Avonia minnewankensis-Marginatia burlingtonensis* Zone, and it is restricted to that zone, occurring only in the western facies. Although it is common in the "upper" member at Lake Minnewanka, GSC locality C-57468, it is much less common elsewhere. Other localities include GSC localities 69571 and 74886.

Avonia? beckerensis n. sp.

Plate 3, figures 21-32

Description. Average size for family, strongly inflated pedicle valve, length and width about equal, greatest width at about mid-length or slightly anterior to mid-length; outline subovate; lateral profile semisubovate; ears small, subangular; trail of moderate length; shell substance thin; thickness of body cavity not known.

Pedicle valve most convex in umbonal region, rather evenly rounded in lateral profile; venter weakly convex, flattened, but sulcus not produced; lateral slopes weakly convex, sloping steeply to lateral commissure; ears delimited by concave flexures; umbo moderately broad, producing an umbonal angle of about 90 degrees; beak small, slightly overhanging hinge line; ornament consisting of very weak, irregular rugae in region of visceral disc, weak, low, scattered, elongate spine ridges in visceral disc region that gradually form low, discontinuous, indistinct costae anteriorly; fine spine bases scattered on umbonal region, group of coarser, erect spines on ears and lateral extremities, concentric rows of spine bases on anterior portion of visceral disc and trail, and distinct, shallow cincture with concentric row of coarse round spine bases near anterior commissure of holotype; ventral interior not observed.

Brachial valve unknown.

Dimensions (mm).

GSC no.	Length	Width	Height	Surface measurement
63238	16.4	16.6	10.5	30.7
63239	14.1	14.0	8.5	24.5
63240	10.9	10.9	7.0	20.1

Type material. Holotype GSC 63238, from GSC locality C-7382, Pl. 3, figs. 21-24. Referred specimen GSC 63239, from GSC locality C-4130, Pl. 3, figs. 25-28; referred specimen GSC 63240, from GSC locality C-86542, Pl. 3, figs. 29-32.

Distinguishing characteristics. This species is characterized by its weakly rugose umbonal region with scattered, fine, elongate spine ridges, weak, discontinuous costae anteriorly, and several concentric rows of spines, the most anterior one forming a shallow cincture in large specimens.

Comparisons. The ornamentation of this species is unlike that of any other described species with which the writer is familiar.

Remarks. Due to the lack of a brachial valve, the assignment of this new and unusual species to a genus is difficult. A cincture in the pedicle valve may be found in several productid families, including the Institinidae, Marginiferidae, Productidae, Overtoniidae, Buxtoniidae and Linoproductiidae. I have arbitrarily assigned this species to the genus *Avonia* with a query on the basis of general shape and ornamentation of the holotype, a pedicle valve. Only the holotype and one other specimen were found in association at the type locality. The two other illustrated pedicle valves are termed referred specimens, not paratypes, because they differ substantially in size or lack the cincture of the holotype.

Distribution. This species appears to be restricted to the *Calvustrigis rutherfordi* Zone of the eastern facies, GSC localities 49690, 49692, 49706, 49721, 66332, C-4130, C-7382, C-11787, C-86542 and C-86545.

Avonia sp.

Plate 6, figures 15-18

Remarks. There are two large specimens of the genus *Avonia* in the collections of the Geological Survey of Canada from the upper Banff Formation at Rundle Mountain, near Banff, Alberta. The smaller and better preserved of the two is illustrated here. Both specimens are strongly inflated pedicle valves with flattened venters and a well developed costate ornament. It is possible that both specimens are somewhat unnaturally compressed dorso-ventrally. Part of the brachial valve of the illustrated specimen also shows a costate

ornament. Neither specimen is very well preserved but it is possible that these specimens represent unusually large *Avonia minnewankensis* (Shimer). There are about five costellae per 3 mm at mid-length. This is approximately the same distance from the ventral beak where authentic *A. minnewankensis* has six to seven costellae per 3 mm. This measurement barely falls within the extreme range of variation in *A. minnewankensis*, and the specific assignment of these two specimens remains uncertain.

Genus *Stegacanthia* Muir-Wood and Cooper, 1960

Stegacanthia gausapa n. sp.

Plate 8, figures 1-9

Description. Medium size for genus; pedicle valve strongly convex, wider than long, greatest width at about mid-length; outline transversely subovate; lateral profile subsemicircular to subguttate; ears small, possibly rounded, flattened; neither valve geniculate; body cavity presumed to be moderately thick, judging by shape of brachial valve.

Pedicle valve almost evenly convex on venter of holotype, with very weak sulcus on paratype; flanks spreading evenly to lateral margins; greatest convexity in umbonal region with maximum height posterior to mid-length; anterior profile subtrapezoidal; beak small, incurved, overhanging hinge line; concentric ornament consisting of irregularly spaced lamellae with numerous elongate spine ridges and fine, prostrate spines on lamellae, some of which may extend onto adjacent lamellae producing vague, finely costate appearance; flanks and anterior half of venter with several irregularly spaced plicae, about twelve on holotype; numerous suberect to erect spines on ears; interior unknown.

Brachial valve with moderately concave visceral disc, trail short or lacking; low fold produced medially; ears delimited by weak convex flexures; flanks evenly concave; ornament consisting of numerous irregular, low rugae, numerous elongate spine ridges, and several irregular plicae; spines fine, numerous, prostrate; cardinal process distinctly trilobed in exterior view; other internal details not observed.

Dimensions (mm).

GSC no.	Length	Width	Height	Surface measurement
63241	36.5	43.5	19.4	60.1
63242	34.1	39.7	20.2	60.0

Type material. Holotype, pedicle valve, GSC 63241, Pl. 8, figs. 1-4, from GSC locality C-86544. Paratypes, pedicle valve, GSC 63242, Pl. 8, figs. 5-8; natural mould of brachial valve interior, GSC 63243, Pl. 8, fig. 9; both from GSC locality C-86544.

Distinguishing characteristics. This species is characterized by its strongly inflated pedicle valve, rounded venter or very weak sulcus, and anteriorly plicate valves.

Comparisons. Stegacanthia gausapa n. sp. is not very similar to other North American species. It is externally similar to the specimen of *Pustula altaica* Tolmachoff illustrated by Sarycheva (1963, Pl. 18, fig. 4). However, the latter species can usually be readily distinguished by its rugose ornament with the spine ridges arranged quincuncially, larger size, and broad, umbonal region.

Distribution. The entire collection of this new species consists of the three illustrated specimens. The author ventures to propose a new species only by virtue of the unique shape and ornament of these specimens. The collection was made by the author at the Canyon Creek Section, 21 feet (6.4 m) below the base of the Pekisko Limestone, *Calvustrigis rutherfordi* Zone, GSC locality C-86544.

Stegacanthia cf. *S. bowsheri* Muir-Wood and Cooper, 1960

Plate 11, figures 7-12

1960 *Stegacanthia bowsheri* Muir-Wood and Cooper, p. 199-200, Pl. 48, figs. 1-12.

Remarks. Collections of pedicle valves from several GSC localities can be readily assigned to the genus *Stegacanthia* Muir-Wood and Cooper.

These pedicle valves have the low profile, transversely subquadrate to subelliptical outine, ventral sulcus and ornamentation of *S. bowsheri* Muir-Wood and Cooper, described from the Lake Valley Formation of New Mexico and also occurring in the lower Burlington Limestone of Missouri. The Banff Formation specimens are very similar in most respects to the Lake Valley types, although they are somewhat smaller than fully mature specimens from New Mexico.

Stegacanthia cf. *S. bowsheri* can be readily differentiated from *S. canyonensis* n. sp. by its smaller size, lower profile, less inflated umbonal region, and well developed ventral sulcus.

Distribution. The first appearance of this species marks the base of the *Stegacanthia* cf. *S. bowsheri-Marginatia ferrglenensis* Zone. It occurs sporadically within this zone in the Bow River valley region of the western facies at GSC localities C-57469, C-57470 and C-57471. At Lake Minnewanka, GSC locality C-57468, this species ranges into the *Avonia minnewankensis-Marginatia burlingtonensis* Zone.

Genus *Piloricilla* n. gen.

Type species. Piloricilla desmetensis n. sp., from the Banff Formation of Alberta.

Diagnosis. Medium sized, strongly inflated overtoniids with subovate outline; lateral slopes steep but flaring at lateral margins; ears small; pedicle valve strongly convex with moderately long trail; brachial valve sharply geniculate producing thick body cavity; ornament of pedicle valve consisting of weak rugae and elongate spine ridges in umbonal region that become almost continuous fine costae anteriorly; trail finely costate; a few coarse plications may be present near lateral and anterior margins; spine distribution consisting of row of spines along hinge line, concentration of erect spines or brush at sides of lateral extremities, scattered spines on visceral disc, usually with concentric row of erect spines near anterior and lateral margins where trail begins to flare, and with other spines on trail scattered on costae or arranged in crudely concentric rows; brachial valve ornament similar but with scattered fine spine bases; cardinal process internally bilobed and externally trilobed, stoutly supported by base of median septum; lateral ridges diverge moderately from hinge line to wrap around ears and unite with obscure marginal rim around visceral disc; brachial ridges given off at about 30 degree angle to hinge line.

Comparisons. The oblique brachial ridges, cardinalia, strongly inflated pedicle valve, and elongate umbonal spine bases that ultimately form costae anteriorly, clearly suggest that this new genus is probably related to one or more of several similar overtoniid genera such as *Acanthocosta* Roberts, *Rhytiophora* Muir-Wood and Cooper, *Semiproductus* Bublichenko, *Spinocarinifera* Roberts, *Protoniella* Bell, and *Nigeroplica* Nalivkin.

Piloricilla n. gen. is most similar externally to the genus *Acanthocosta* Roberts, 1971, from the Tournaisian of Australia. The latter differs in lacking spines along the hinge line, has many more numerous fine spines on the costae, and lacks the flared lateral margins of *Piloricilla* n. gen. Internally, *Acanthocosta* has lateral ridges that do not diverge appreciably from the hinge line and terminate before reaching the cardinal extremities. It apparently lacks the ridges around the ears and margins of the visceral disc as seen in *Piloricilla* n. gen.

Rhytiophora Muir-Wood and Cooper and *Semiproductus* Bublichenko are similar overtoniid genera that share some external and internal similarities with *Piloricilla* n. gen. *Rhytiophora* has a much shorter trail, much stronger elongate spine ridges on the ventral umbo, stronger umbonal rugae on both valves, and weaker, coarser costae than *Piloricilla.* Internally, *Rhytiophora* has brachial ridges given off at a very low angle or almost parallel to the hinge line. *Semiproductus* has weak to obscure discontinuous ribbing in most species, lacks spines on the brachial valve, has parallel or very steep non-flaring lateral slopes, and a well developed fold and sulcus in the type species. Internally, it apparently lacks ridges around the ears but has dendritic adductor scars, which are lacking in *Piloricilla.*

Another Australian genus, *Spinocarinifera* Roberts, is somewhat similar externally, especially in outline and profile, to this new genus. However, *Spinocarinifera* has stronger ribbing, nonflaring lateral margins, quite a different spine distribution on the pedicle valve, and lacks spines on the brachial valve. Internally, the cardinal process has an alveolus and the lateral ridges diverge very little from the hinge line.

Roberts (1971, p. 115) recently redescribed the brachial valve interior of a paratype of the type species of the genus *Protoniella* Bell. He concluded that *Protoniella* belongs to the Overtoniidae, not to the Buxtoniidae, where it had been placed by Muir-Wood and Cooper. Although the shape, outline, and ornamentation of the pedicle valves of *Protoniella* are similar to those of *Piloricilla* n. gen., the former can be readily differentiated by its non-geniculate brachial valve with thin body cavity, short trails, lack of flared lateral margins, lack of spines on the brachial valve, and umbonal cicatrix on some of the pedicle valves. Internally, *Protoniella* has a deep, round alveolus.

Nalivkin (1975, p. 160) recently proposed a new genus, *Nigeroplica*, based on the oft-cited Etroeungtian species, *Productus niger* Gosselet. Unfortunately, *Productus niger* is known only from external descriptions and its true affinities are uncertain. It has subparallel sides and relatively coarse costae and is apparently not very similar to this new genus. Roberts (1971, p. 101) tentatively assigned *P. niger* to his genus *Spinocarinifera* on the basis of external morphology.

A new genus, *Kadraliproductus*, of possible overtoniid affinities, from the Viséan and Namurian of the Kirgiz, U.S.S.R., was recently proposed by Galitskaya (1977, p. 36, 37). *Kadraliproductus* is similar to *Piloricilla* n. gen. in outline and profile but differs in having a strongly reticulate visceral disc with strong sinuous rugae. Internally, the lateral ridges are short, not reaching the ears.

Species assigned. Apart from the type species only *Productus sedaliensis* Weller, from the Chouteau Limestone of Missouri, and an unnamed new species from the Gilmore City Limestone of Iowa, can be placed here with reasonable confidence.

Productus sciotoensis Hyde, from the Logan Formation of Ohio, is similar to *Piloricilla desmetensis* n. sp. in several external details, but lacks flaring lateral margins. Dorsal interiors have not been described for this species.

Productus vaughni Muir-Wood, from the Tournaisian of England, may belong to this new genus. However, the dorsal interior illustrated by Muir-Wood (1928, Pl. 2, fig. 13a) has lateral ridges that diverge at an unusually high angle from the hinge line.

Protoniella? waggonensis Roberts, from the Tournaisian of Australia, has a short trail and does not flare at the lateral margins, but otherwise fits the diagnosis given above for this new genus.

Derivation of name. Latin, *pilosus*, hairy; and Latin, *oricilla*, small ear, referring to the brush of fine spines on the lateral extemities or "ears" of the pedicle valve.

Stratigraphic range. Tournaisian.

Piloricilla desmetensis n. sp.

Plate 9, figures 9-35; Plate 12, figures 10-15

Description. Medium size for family, pedicle valve strongly convex, gibbous; length and width about equal, greatest width usually attained anterior to mid-length in adults; outline transversely to longitudinally subovate; outline of visceral region subquadrate to subsemicircular; lateral profile of pedicle valve subsemicircular to subguttate; ears small, slightly compressed; pedicle valve evenly rounded to slightly geniculate, brachial valve strongly geniculate; moderately long trails produced in both valves with lateral margins flaring in adults; body cavity moderately thick.

Pedicle valve visceral disc strongly convex except for concave flexures near cardinal extremities; flanks and trail less convex, sloping steeply to lateral and anterior margins; venter evenly convex to flattened, rarely with weak sulcus; anterior profile subtrapezoidal to subquadrate; beak small, slightly overhanging hinge line; ornament of visceral disc consisting of elongate spine ridges that increase in length anteriorly, becoming almost continuous, fine costae on trail, with about ten to fifteen, usually twelve to fifteen per centimetre at anterior margin; spine ridges on visceral disc crossed by narrow, weak, irregular rugae forming weak, reticulate ornament, strongest on flexures defining ears; costae on middle of trail rarely discontinuous, increasing by bifurcation or intercalation; costae on lateral slopes usually coarser, less distinct, and commonly discontinuous; few weak, coarse plications occasionally found at lateral and anterior margins; spine pattern consisting of sparse row of fine, laterally directed spines at hinge line; one or several rows of fine spines curving from under umbo around ears and down lateral extremities, several coarse, erect spines at sides of lateral extremities commonly forming dense brush, several crudely concentric rows on trail, especially near margins, and scattered spine bases on visceral disc and trail; growth lines fine, irregularly spaced.

Pedicle valve interior with deeply incised posterior adductors; anterior adductor scars variable, occasionally found elevated on callus in large specimens; diductor scars

large, deeply grooved longitudinally, flabellate, enclosing adductors.

Brachial valve with weakly to moderately concave visceral disc with small convex flexures defining ears; trail and lateral slopes weakly concave to flattened; visceral disc with scattered pits and radially aligned, elongate grooves in posterior part, becoming virtually continuous intercostal furrows anteriorly and on trail; entire visceral disc weakly rugose and reticulate; rugae low, fine, closely spaced; costae on trail and lateral slopes similar to those of opposite valve; spine bases of fine, low or nearly prostrate spines present, density not determinable.

Brachial valve interior with small, sessile cardinal process, bilobed in internal view, or trilobed, if median lobe elongate; in external view cardinal process trilobed with straight, rounded median lobe and deeply concave myophore groove on each side; median septum broad, occasionally found with shallow longitudinal depression posteriorly, fused with base of cardinal process and lateral ridges to form posterior platform; septum extending forward about two thirds of length of visceral disc as low, thin blade; cardinal process occasionally found also weakly buttressed by short, anterolateral ridges that enclose posterior adductor field; lateral ridges fused with cardinal process and septum medially, extending laterally, diverging gradually from hinge line, then curving as broad ridge around ear, joining low, obscure, marginal ridge that extends around lateral and anterior margins of visceral disc in adults; brachial ridges lobate with outer edges at about 30 degree angle from hinge line; adductor scars not dendritic, posterior pair with few longitudinal grooves, anterior pair slightly elevated and smooth or vaguely grooved; weak impression of external ribbing developed on anterior internal surface of visceral disc; a few coarse endospines developed on marginal ridge, numerous fine endospines on trail.

Dimensions (mm).

GSC no.	Length	Width	Height	Thickness	Surface measurement
63246	21.4	25.6	14.1	7.2	40.9
63247	25.4	26.9	16.5	-	47.3
63248	28.6	24.8	11.9	-	47.0
63249	21.0	18.8	14.5	9.0	-
63250	19.0	17.4	12.0	-	34.1

Type material. Holotype GSC 63246, from GSC locality 49706, Pl. 9, figs. 9-13, 18. Paratypes GSC 63247, 63248 and 63250, three pedicle valves from GSC localitites 49706, C-7388, and C-4130, respectively, Pl. 9, figs. 14-17, 19-22, 31-34; paratype GSC 63249, a nearly complete specimen from GSC locality C-4130, Pl. 9, figs. 23-28; paratype GSC 63251, a mould of a brachial valve exterior from GSC locality C-4130, Pl. 9, figs. 29, 30, 35; paratypes GSC 63252 and 63253, two brachial valves from GSC locality C-7388, Pl. 2, figs. 10-15.

Distinguishing characteristics. This species can be differentiated by its strongly convex pedicle valve, geniculated brachial valve, flared lateral margins, finely costate trails, elongate spine ridges, and weakly rugose, slightly reticulate visceral discs. On the pedicle valve there is a row of fine spines at the hinge line, one or several rows of spines curving from under the umbo and around the ears, a brush of coarse, erect spines at the sides of the lateral extremities, and several crudely concentric rows of erect spines on the trail. The brachial valve ornament is complementary, but the distribution of spines has not been determined. Internally, the brachial valve has lateral ridges that extend around the ears and join a low obscure marginal rim, and the brachial ridges are at a 30 degree angle to the hinge line.

Comparisons. Two other previously described North American species are similar to *Piloricilla desmetensis* n. sp., viz. *Productus sedaliensis* Weller from the Chouteau Limestone of Missouri, and *Dictyoclostus sciotoensis* Hyde, from the Logan Formation of Ohio.

Productus sedaliensis Weller can be distinguished by its larger size, coarser costae, and fewer spines at the sides of the lateral extremities. *Dictyoclostus sciotoensis* Hyde, differs from *Piloricilla desmetensis* by its slightly larger size, better defined costae, which clearly bifurcate on the trail, less convex venter, straight lateral slopes that do not flare out at the lateral margins, and less distinct ears.

Remarks. A productid species from the Gilmore City Limestone of Iowa described as *Buxtonia* sp. A by Carter (1972, p. 478-480) appears to be similar to this new Banff species. The Gilmore City Limestone specimens have a flared trail similar to that of the Banff specimens, a character Carter discounted at the time, assuming it to be an artifact due to preservation. Also, the poor dorsal interiors available from the Gilmore City Limestone specimens do not show the lateral ridges joining a marginal rim at the ears, but they are too poorly preserved for a conclusive judgement about this character to be made.

Distribution. Piloricilla desmetensis n. sp. is one of the most widely distributed species in the *Calvustrigis rutherfordi* Zone of the eastern facies, occurring at most stratigraphic sections in the eastern facies at the following GSC localities: 31347, 31349, 36760, 36777, 49688, 49690, 49692, 49695, 49706, 49709, 49721, 49727, 49728, 49730, 49733, 49753, 49754, 66327, 66329, 66330, 66331, 68486, 68516, 68518, 68571, 74866, C-4129, C-4130, C-7388, C-11787, C-86542, C-86543, C-86544 and C-86545. It is also a good indicator of this zone in the western facies, occurring in the "middle" member at GSC localities 62101, 69554 and 73521.

Overtoniid gen. et sp. indet. A

Plate 7, figures 32-35

Remarks. A medium size pedicle valve from GSC locality C-11787 is not assignable to a known species. It is strongly and evenly inflated in lateral profile, with a slight flattening on the venter and a very faint sulcus. Length and width are nearly equal, being 26.0 mm and 26.7 mm, respectively, with greatest width apparently attained anterior to mid-length, although both lateral extremities are missing. Ornament is typical for several genera of the family Overtoniidae, with weak rugae and elongate spine bases posteriorly, the latter producing weak, discontinuous costae over much of the remainder of the valve. Spine bases are more or less in quincunx posteriorly, becoming more scattered on the crests of the costae anteriorly. There are numerous fine spines near the hinge on each side of the umbo. The ears are not preserved.

The umbo is too broad and the costae too weak for this to be an *Avonia* s.s. or *Spinocarinifera*. In size and ornament it possibly resembles most closely the large specimen of *Quasiavonia* figured by Brunton (1966, Pl. 10, figs. 8-10), but the Banff specimen is too inflated and its umbo is much too broad. To a lesser extent, it resembles the genus *Semiproductus*, but the latter usually has a more strongly rugose visceral disc, coarser costae on the trail, and the pedicle valve is usually distinctly geniculate, not evenly inflated as in the specimen at hand.

Overtoniid gen. et sp. indet. B

Plate 7, figures 27-30

Remarks. This medium size pedicle valve, from GSC locality 49692, is similar to the preceding pedicle valve, but differs in having a well rounded venter, fine costae that extend almost to the beak, and is somewhat smaller. It is closer to *Avonia* in general aspect than to any other genus, but is much more transverse, with a broader and shorter umbo, than other North American species of that genus.

Family TOLMATCHOFFIIDAE Sarycheva, 1963

Genus *Setigerites* Girty, 1939

Setigerites jasperensis (Warren), 1932

Plate 10, figures 1-28; Plate 12, figures 1-9

1932 *Productus jasperensis* Warren, p. 243-244, Pl. 1, figs. 1-6.

1952 *Dictyoclostus jasperensis* (Warren). Brown, p. 87.

1961 *Dictyoclostus jasperensis* (Warren). Nelson, Pl. 5, figs. 6-8; Pl. 7, figs. 15-17.

1970 *Marginatia jasperensis* (Warren). Bamber and Copeland, Pl. 12, fig. 6a, b.

Description. Average size for genus, strongly gibbous, slightly longer than wide, position of maximum width variable, commonly anterior to hinge line; outline subovate to almost subquadrate; outline of visceral region semicircular to subquadrate; ventral umbo massive, broad; ears small, subangular, compressed, well defined by sharp flexures; brachial valve geniculate; moderately long trails produced; body cavity thick; anterior margins of both valves moderately reflexed forming spreading marginal rim.

Pedicle valve most convex in umbonal region, otherwise almost evenly convex in lateral profile, venter evenly rounded, flattened, or weak shallow sulcus occasionally formed; flanks dropping steeply to slightly or moderately spreading lateral margins; beak small, incurved, slightly overhanging hinge line; radial ornamentation consisting of elongate spine ridges in umbonal region that coalesce to form discontinuous or irregularly continuous fine costae anteriorly that increase by both intercalation and bifurcation, with approximately twelve to fifteen costae per centimetre, usually thirteen or fourteen near anterior margin; visceral disc with weak to moderate, irregularly spaced rugae forming weakly reticulate pattern on venter; spine ridges on flanks near ears usually continuous, rarely forming costae; trail usually with well defined, continuous costae, occasionally with irregular plications at margins; rim or gutter lacking radial ornament; spines on venter, flanks and trail very fine; slightly coarser spines found as row along hinge line, and several additional rows that curve from beak around ears forming brushes at cardinal extremities; growth lines very fine and sinuous; interior details not observed.

Brachial valve strongly geniculate with weakly concave visceral disc; trail at about 90 degrees to visceral disc; ears delimited by convex flexures; dorsum evenly concave to flattened or, rarely, with low obscure fold; radial ornament consisting of fine costae that originate obscurely near hinge line and increase most commonly by intercalation; costae on visceral disc often sinuous, irregular, or discontinuous, those on trail usually well defined; visceral disc weakly reticulate as on pedicle valve; spine bases or spines *per se* not observed, but very fine, elongate spine tubules present in outer shell layers.

Brachial valve interior with short, stout, sessile cardinal process, trilobate in both internal and exterior views, inclined dorsally from plane of visceral disc; median septum stout at base, supporting cardinal process, extending forward two thirds to three fourths of length of visceral disc, becoming blade-like anteriorly; lateral ridges extending along hinge line, diverging slightly, reaching cardinal extremities; slightly thickened rim produced around entire visceral disc; brachial ridges well developed, at low angle to horizontal; adductor platform coarsely dendritic, trigonal; trail covered with numerous endospines, substantially thickened.

Dimensions (mm).

Type no.	Length	Width	Height	Thickness	Surface measurement	Marginal ribs/cm
GSC 63256	41.5	39.6	22.5	-	69.5	13
GSC 63257	34.5	36.0	18.7	-	58.9	13
GSC 63258	33.3	40.6	18.9	-	60.5	13
UA Cb 278	33.0	33.2	17.6	-	56.0	14
UA Cb 275	29.4	28.7	20.0	-	54.8	14
GSC 63259	28.9	26.8	19.3	11.9	50.0	12
UA Cb 274-77	31.1	34.0	-	-	42.8	-

Type material. Warren's five syntypes and a natural mould of a brachial valve of one of them are in the collection of the Department of Geology, University of Alberta, numbers Cb 273-278.

Distinguishing characteristics. This species is characterized by its broad ventral umbonal region, reticulate visceral disc, commonly discontinuous or irregularly continuous costae, especially on flanks and umbonal region, and thickened dorsal trail. Internally, the cardinal process is quite short and stout and the brachial ridges are horizontal or parallel to the hinge line.

Comparisons. There are no North American species of the genus *Setigerites* Girty that are very similar to *S. jasperensis*. *Productus viminalis* White from the upper Burlington and Keokuk limestones of the upper Mississippi Valley region possibly belongs to *Setigerites*. This species is substantially larger and has much coarser costae than *S. jasperensis*. *Productus newtonensis* Moore, from the Reeds Spring Limestone of southwestern Missouri probably also belongs to this genus, but it is also much larger than *S. jasperensis* and has a pronounced ventral sulcus and regular uninterrupted costae. *Setigerites facetus* Carter, recently described (1983, p. 62-66) from the Humboldt Oolite (Gilmore City Limestone) of northcentral Iowa, is nearly the same age as *S. jasperensis* but can be distinguished readily by its much smaller size, narrower umbonal region, sparse spine brushes on the ears, and lack of a marginal rim or gutter.

Setigerites jasperensis (Warren) is most similar to *S. lichwiniformis* Sarycheva from the Tournaisian of the Kuznets Basin. The latter differs by the following minor details: both valves are described by Sarycheva (1963, p. 184) as being thin (the dorsal trail in *S. jasperensis* is thickened), and the cardinal process is bilobed in ventral view, whereas the cardinal process of *S. jasperensis* is usually trilobed in this view, the median lobe being well fused even on the internal surface. These small differences may not be of specific importance.

Distribution. Setigerites jasperensis is widely distributed in the *Calvustrigis rutherfordi* Zone of the eastern facies and is particularly common in the Jasper region. It occurs in

collections from the following GSC localities: 18553, 31349, 37131, 40263, 49688, 49690, 49692, 49695, 49704, 49705, 49707, 49721, 49726, 49730, 49734, 49735, 49736, 49740, 49744, 66038 and 66331. In addition, it occurs in this zone in the "middle" member at GSC locality 62101 in the Bow River valley of the western facies.

It should be noted that a closely related subspecies occurs in the uppermost Pekisko Formation and lowermost Shunda Formation in the Cadomin area.

Setigerites newtonensis (Moore), 1928

Plate 11, figures 5, 6

1928 *Productus newtonensis* Moore, p. 267-268, Pl. 10, figs. 12, 13.

1963 *Setigerites newtonensis* (Moore). Sarycheva, p. 182-183, Pl. 25, fig. 1.

Remarks. A single, nearly complete but partially crushed, large productid from GSC locality C-57474 appears to be very similar to the holotype of *Setigerites newtonensis* (Moore), which was described from the Reeds Spring Limestone of southwestern Missouri.

A dense brush of spine bases on the ears, and a distinctive gutter-like rim around the trail on the Canadian specimen supports Sarycheva's assignment of this species to the genus *Setigerites* Girty. I have examined Moore's types; the holotype bears a dorsally directed cardinal process, but the distal portion of the trail with a flaring rim or gutter is not preserved. However, Moore's paratype does show the flaring trail or gutter that is characteristic of *Setigerites*.

Distribution. This specimen was collected by the author from an indeterminate horizon in the "upper" member of the Banff Formation south of the Bow River valley along the Kananaskis Highway.

Family ECHINOCONCHIDAE Stehli, 1954

Subfamily ECHINOCONCHINAE Stehli, 1954

Genus *Pustula* Thomas, 1914

Pustula cf. *P. pustulosa* (Phillips), 1836

Plate 8, figures 10-19

1836 *Producta pustulosa* Phillips, p. 216, Pl. 7, fig. 15.

Description. Medium size for genus, pedicle valve strongly convex, slightly wider than long, with greatest width at or slightly posterior to mid-length; outline in ventral view transversely subovate to subquadrate; lateral profile subguttate; ears small, possibly rounded; neither valve notably geniculate; ventral trail of moderate length; dorsal trail not observed; thickness of body cavity not observed.

Pedicle valve most convex in umbonal region, with steep lateral slopes that spread evenly to lateral margins where they flare in some specimens; small, spreading ears defined by concave flexures; venter with shallow sulcus that originates in umbonal region; anterior profile subtrapezoidal; beak small, incurved, overhanging hinge line; ornament consisting of numerous, low, somewhat irregular, concentric rugae and many slightly elongate spine ridges, mostly set on rugae in crudely quincuncial arrangement; spine ridges not formed near anterior margin, spine bases at margin round, erect; interior not observed.

Brachial valve exterior not observed; interior with internally bilobate and externally trilobate, dorsally recurved cardinal process supported by broad base of median septum, which narrows abruptly posteriorly to form narrow, blade-like septum in adductor region; lateral ridges curved posteromedially to give stout support to cardinal process shaft, extending laterally along hinge line, not diverging, not reaching cardinal extremities; two small, bulbous tubercles produced on posteroventral surface of cardinal process where shaft bends at right angles to plane of dorsal visceral disc; internal surface rugose with elongate prostrate endospines; other internal details not observed.

Dimensions (mm).

GSC no.	Length	Width	Height	Surface measurement
63265	30.8	32.2	15.8	43.5
63266	33.7	36.6	18.6	60.0
63267	32.2	34.8	18.5	53.4

Remarks. True *Pustula* species have rarely been reported in the Mississippian of North America. Most published references to this genus appear to have been misidentified or would now be referred to other similar genera, such as *Stegacanthia* Muir-Wood and Cooper or *Scutepustula* Sarycheva. Although this Banff form has slight differences in the dorsal interior from the type species, *Pustula pustulosa*, as described by Muir-Wood and Cooper (1960, p. 250, 251), there is little doubt about the generic assignment.

In the absence of similar North American species with which to compare this form, and considering the small number of specimens available, I have chosen to compare this Banff *Pustula* with the type species, *Producta pustulosa* Phillips, which is of Viséan age and found in Western Europe and the Soviet Union, thus emphasizing the generic affinity of the Banff species.

A similar rare but undescribed species occurs in the Madison Limestone of the western United States.

The Banff species differs from *Pustula pustulosa* in being more strongly convex, relatively thicker with a larger, more gibbous ventral umbonal region, and has more numerous spines on the pedicle valve. It is similar in some respects to *Pustula pustuliformis* Rotai from the Tournaisian of the Soviet Union, but the latter differs mainly in having very elongate spine ridges on the pedicle valve; those of the Banff species are only slightly elongate in the middle of the pedicle valve and are round anteriorly and posteriorly.

Distribution. This Banff *Pustula* has been found at only three GSC localities: 18550, 18558 and 69565. Two of the pedicle valves from GSC locality 18550 have discrete partial brachial valve interiors embedded in matrix on the dorsal surfaces of the specimens.

GSC localities 18550 and 18558 both occur within the *Calvustrigis rutherfordi* Zone of the eastern facies. The single specimen from GSC locality 69565 comes from the "upper" member at Pigeon Mountain in the Bow River valley, from a horizon most probably low in the *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone.

Pustula morrocreekensis n. sp.

Plate 11, figures 24-32

Description. Small to medium size for genus, transversely subsemicircular to subovate in outline, moderately concavo-convex, wider than long; position of greatest width variable from hinge line to about mid-length; fold and sulcus not developed; lateral profile low, semilenticular; ears moderately well developed, subangular, delimited by concave flexures; trails short, body thin to medium in thickness.

Pedicle valve weakly to moderately inflated, most convex umbonally, evenly convex on venter and anterolateral flanks, with moderately compressed ears; anterior profile sublenticular; beak small, incurved, slightly overhanging hinge line; ornament: numerous narrow, irregular, occasionally discontinuous rugae over entire surface, with numerous small, elongate spine ridges roughly arranged in quincunx and usually set on rugae; spines not observed but probably very fine and subprostrate; growth lines prominent, sinuous, closely spaced; interior details not observed.

Brachial valve moderately concave, most concave mid-posteriorly, forming narrow depression between almost flat cardinal extremities, rest of valve weakly concave; ornament: few to numerous, irregular, discontinuous, low rugae much weaker than those of pedicle valve, with numerous, fine, elongate pits crudely arranged in quincunx, especially posteriorly, and numerous very fine spine bases roughly arranged in concentric rows; growth lines as in opposite valve; interior with narrow elongate cardinal process, bent dorsad; median septum extending anteriorly slightly more than half of valve length; other internal details not observed.

Dimensions (mm).

GSC no.	Length	Width	Height	Thickness	Surface measurement
63270	24.6	30.9	±11.0	5.3	34.0
63269	±28.0	±30.0	11.7	8.4	±42.0
63268	20.9	±26.5	8.1	4.5	30.0

Type material. Holotype GSC 63270, Pl. 11, figs. 29-32 from GSC locality 49688. Paratypes GSC 63268 and 63269, Pl. 11, figs. 24-28; GSC localities 49709 and 18555, respectively.

Distinguishing characteristics. This species is characterized by its small to moderate size, lack of fold and sulcus, well developed ears, numerous closely spaced rugae, and numerous fine spine ridges.

Comparisons. Pustula morrocreekensis n. sp. is not very similar to most species of the genus *Pustula* because of its modest size, fine ornamentation, and lack of fold and sulcus.

It is similar to *Pustula echinata* Moore from the Chouteau Limestone of Missouri in having fine ornamentation and no fold and sulcus. *Pustula echinata* can be readily differentiated by its smaller size, more elongate outline, more inflated profile, narrower ventral umbonal region, more widely spaced concentric rows of spines, and smaller, less well developed spine ridges.

Distribution. This species is seemingly found only in the *Calvustrigis rutherfordi* Zone of the eastern facies. It has been recovered from the following GSC localities: 18559, 49688, 49695, 49707, 49709, 74860 and C-11787.

Derivation of name. After Morro Creek.

Family BUXTONIIDAE Muir-Wood and Cooper, 1960

Genus *Tomiproductus* Sarycheva, 1963

Tomiproductus gallatinensis (Girty), 1899

Plate 4, figures 27-45; Plate 7, figures 31, 36

1899 *Productus gallatinensis* Girty, p. 533-534, Pl. 68, figs. 7a-c, 11a-d.

Description. Average size for genus, concavo-convex, length and width nearly equal, greatest width usually attained at hinge line or about mid-length; outline subovate to subquadrate; outline of visceral disc subquadrate to semisubovate; lateral profile subtrigonal to subguttate; ears of moderate size, well defined, subangular, slightly mucronate; both valves geniculate; trail moderately long; body cavity thick.

Pedicle valve strongly inflated, most convex in umbonal region and at point of geniculation; venter usually flattened, shallow sulcus rarely produced; flanks weakly convex, sloping steeply to lateral margins; lateral extremities nearly vertical; ears delimited by concave flexures; umbonal region broad, swollen, with umbonal angle greater than 90 degrees; beak small, overhanging hinge line; ornament consisting of numerous rounded costellae, about seven to eleven per 5 mm on trail near mid-anterior margin, originating near beak but usually weaker posteriorly and occasionally obsolescent on trail near anterior margin; intercostal furrows narrower than costellae; weak irregular rugae on visceral disc, weakest on venter, strongest on ears; spine bases scattered over whole valve on crests of costellae, becoming coarser anteriorly; row of fine spines along hinge line; growth lines very fine, irregularly spaced; diductor scars large, flabellate, longitudinally grooved; other internal details not observed.

Brachial valve weakly concave on visceral disc with convex flexures and posteromedial depression delimiting ears; posteromedial node present at hinge line; trail strongly geniculate, moderately long, weakly concave; ornament consisting of costellae and rugae as in pedicle valve; spine bases not observed; growth lines as on opposite valve; cardinal process short, sessile, bilobed or trilobed in internal view, trilobed in external view, supported by broad base of median septum, which narrows and extends forward about one half to two thirds of visceral disc length; lateral ridges well defined, extending along hinge line almost to cardinal extremities before diverging slightly near ears; brachial ridges given off at very low angle to hinge line, enclosing lobate scars; adductor scars smooth, subtrigonal, raised on low platform; trail with numerous, low, elongate, radially arranged endospines.

Dimensions (mm).

GSC no.	Length	Width	Height	Thickness	Surface measurement
10080	21.8	20.0	13.3	-	40.8
10080d	23.9	22.1	15.2	-	45.3
10080e	24.2	23.9	16.4	-	47.2
63272	21.4	18.4	13.2	9.3	40.3

Type material. Girty's type specimen is in the collections of the National Museum of Natural History, Washington, D.C., U.S.A., number 35169. The paratype illustrated by Girty (1899, Pl. 68, fig. 7a-c) may not belong to this species, as Girty himself noted (op. cit., p. 533).

Distinguishing characteristics. ***Tomiproductus gallatinenesis*** is characterized externally by its broad umbo, nearly equal length and width, and ornamentation of about seven to eleven costellae per 5 mm on the trail that tend to become obsolescent near the anterior margin. Internally, the lateral ridges extend along the hinge line almost to the cardinal extremities before diverging slightly near the ears, and the radial ridges are given off at a low angle to the hinge line.

Comparisons. ***Tomiproductus gallatinensis*** is not very similar to most other North American Lower Carboniferous productids. Girty (1899, p. 533) compared it to ***Productus parviformis*** Girty, another Madison Limestone species, which is described in the same paper, but the latter is much smaller, with relatively coarser ribbing.

Outside North America, ***Tomiproductus elegantulus*** (Tolmachoff) and ***T. dukhovae*** Sarycheva, both from the Tournaisian of the Kuznets Basin in the Soviet Union, are similar to ***T. gallatinensis*** in many details. ***Tomiproductus elegantulus*** differs as it is typically slightly smaller, usually has slightly finer costellae and a proportionately longer trail. Internally, ***T. elegantulus*** has a shallow antron, a longer median septum, and the lateral ridges diverge from the hinge line slightly more than in ***T. gallatinensis.*** ***Tomiproductus dukhovae*** differs in being slightly longer with slightly coarser, more prominent costellae. In terms of total range of size, proportions, coarseness of ribbing, and spine density, these three species all intergrade to some degree. Most Banff Formation specimens are smaller than those illustrated in Plate 4 and could readily be identified as ***T. elegantulus,*** which is a highly variable species, according to Sarycheva (1963, p. 204, 205).

Distribution. Few species in the Banff Formation brachiopod fauna have a more enigmatic stratigraphic distribution than ***T. gallatinensis.*** In the Jasper region, eastern facies, ***T. gallatinensis*** is found only in the Banff Formation, ***Calvustrigis rutherfordi*** Zone. At Sunwapta Pass it occurs in association with several species that strongly suggest the ***Stegacanthia*** cf. ***S. bowsheri-Marginatia ferglenensis*** Zone. But in the Bow River valley region and at Lake Minnewanka it occurs well up in the ***Avonia minnewankensis-Marginatia burlingtonensis*** Zone. These collections are from the following GSC localities: 18527, 49707, 49709, 59140, 62111, 69571 and C-57468.

Genus ***Flexaria*** Muir-Wood and Cooper, 1960

Flexaria n. sp.

Plate 11, figures 20-23

Remarks. A single, moderately well preserved, medium sized pedicle valve from GSC locality 18527 near Sunwapta Pass appears to be assignable, on the basis of external characteristics, to the genus ***Flexaria*** Muir-Wood and Cooper. The faunal assemblage from this collection is characteristic of the ***Stegacanthia*** cf. ***S. bowsheri-Marginatia ferglenensis*** Zone.

There are three other species of ***Flexaria*** described from the Lower Mississippian of North America, viz. ***Flexaria floydensis*** (Sutton) from the Upper Borden Group of Indiana and Kentucky, ***F. annosa*** (Herrick) from the Cuyahoga Formation of Ohio, and ***F. galeana*** (Girty) from the Madison Limestone of Idaho. All three of these species have somewhat coarser costae than the Banff Formation specimen. In addition, ***Flexaria floydensis*** lacks a median sulcus in the pedicle valve, ***F. annosa*** is much more transverse with a wider hinge line, and ***F. galeana*** is more transverse, has a wider hinge line, lacks a sulcus, and has a weakly semireticulate ventral umbo.

Flexaria n. sp. has a subtrigonal outline, a shallow but well produced ventral sulcus, narrow hinge line, and lacks rugae on the ventral umbonal region.

Although these distinctive characteristics suggest that the Banff specimen represents an undescribed species, the author hesitates to propose a new name on the basis of a single specimen.

Genus ***Marginatia*** Muir-Wood and Cooper, 1960

Marginatia ferglenensis (Weller), 1909

Plate 11, figures 13-19

1909 ***Productus ferglenensis*** Weller, p. 299-300, Pl. 12, figs. 14-17.

1960 ***Marginatia ferglenensis*** Weller. Muir-Wood and Cooper, p. 412, Pl. 99, figs. 7-9, 15, 16.

Remarks. Weller (1909) described ***Productus ferglenensis*** from the Fern Glen Formation of Missouri. Some larger specimens from the Fern Glen are somewhat more robust than the specimens from the Banff Formation. ***Marginatia ferglenensis*** is also quite common in the lower Burlington Limestone of eastern and central Missouri, a lateral time equivalent of the Fern Glen Formation. These specimens are smaller but otherwise very similar to the Fern Glen specimens. The Banff specimens are virtually indistinguishable from the lower Burlington individuals.

In Missouri, ***Marginatia ferglenensis*** does not occur above the ***Cryptoblastus melo*** Zone and is a very good indicator of early Osagean age.

Distribution. This species has been found only in the "upper" member of the Banff Formation in the Bow River valley region. The specimens from GSC localities C-57469, C-57470 and C-57471 are from the ***Stegacanthia*** cf. ***S. bowsheri-Marginatia ferglenensis*** Zone. It ranges into the ***Avonia minnewankensis-Marginatia burlingtonensis*** Zone at Pigeon Mountain, GSC locality 69572.

Marginatia burlingtonensis (Hall), 1858

Plate 9, figures 1-8

1858 ***Productus flemingi*** var. ***burlingtonensis*** Hall, p. 598, Pl. 12, fig. 3a-g.

Remarks. Poorly preserved specimens of this species are moderately common in the "upper" member of the Banff Formation, western facies, at several localities. Rare, well preserved specimens are generally similar in all respects with the common and well known ***Marginatia burlingtonensis*** (Hall) of the upper Mississippi Valley region. As far as the author can determine, the latter is not found in the lower Burlington Limestone in the midcontinental region. It ranges throughout the upper Burlington but is replaced by ***Marginatia mesialis*** (Hall) in the Keokuk Formation. Hence, its stratigraphic range appears to be restricted to mid-Osagean and is taken to indicate that age in the Canadian Rockies.

Marginatia burlingtonensis has been reported from the Banff and Rundle formations of western Alberta by several authors, including Shimer (1926), Warren (1927), Harker and Raasch (1958), and Nelson (1961). The specimen identified as *Dictyoclostus burlingtonensis* (Hall) and figured by Nelson (1961, Pl. 12, figs. 4, 5) would probably be more appropriately referred to the genus *Inflatia* Muir-Wood and Cooper.

Distribution. The first appearance of this species marks the base of the *Avonia minnewankensis-Marginatia burlingtonensis* Zone, the uppermost brachiopod zone of the Banff Formation. In the Bow River valley region this zone extends into the basal Livingstone Formation. Some of the finest specimens of this species occur in these Livingstone beds. In the Banff Formation it occurs at GSC localities 74886, 74887 and 74893.

Family LINOPRODUCTIDAE Stehli, 1954

Subfamily LINOPRODUCTINAE Stehli, 1954

Genus *Ovatia* Muir-Wood and Cooper, 1960

Ovatia prolata n. sp.

Plate 5, figures 1-17

Description. Average size for genus, strongly gibbous, usually longer than wide with maximum width attained anterior to mid-length; outline subovate; ventral umbo very gibbous, of moderate width, overhanging hinge line; ears small, wrinkled, well defined by sharp flexures; brachial valve geniculate; trails of both valves moderately long; body cavity relatively thick for genus.

Pedicle valve most convex in umbonal region, with convexity usually decreasing gradually anteriorly; lateral profile strongly gibbous; flanks sloping steeply or moderately spreading in some specimens; venter evenly rounded in most specimens, anterior profile subsemiovate; beak small, narrow, incurved; entire surface costellate with about thirty to forty costellae per 10 mm, usually thirty-two to thirty-four, as measured 25 mm from ventral beak (surface measurement); costellae increase by intercalation; four or five strong rugae produced as broad wrinkles on each side of umbonal region; growth lines very faint, closely spaced; rare, small spine bases on venter and flanks; dense brush of medium spines extending along hinge line and over ears; interior details not observed.

Brachial valve moderately geniculate with moderately concave visceral disc; trail approximately at right angles to visceral disc in only specimen observed; ears delimited by convex flexures; dorsum evenly concave; entire surface costellate but costellae increase by bifurcation as well as intercalation; visceral disc moderately to weakly rugose, rugae strongest at lateral extremities and at anterior edge of disc; spines not observed; cardinal process small, bilobed; lateral ridges short, not diverging appreciably from hinge line; other internal details not observed.

Dimensions (mm).

GSC no.	Length	Width	Height	Thickness	Surface measurement
63279	28.8	36.2	22.3	9.1	54.8
63280	29.5	28.6	18.7	-	51.0
63281	32.8	24.6	21.6	-	57.2
63282	37.0	26.1	22.5	-	62.0

Type material. Holotype GSC 63281, Pl. 5, figs. 11, 12, 16, 17, from GSC locality C-86543. Paratypes GSC 63279 and 63280, Pl. 5, figs. 1-10, from GSC locality C-86542; GSC 63282, Pl. 5, figs. 13-15, from GSC locality C-86543.

Distinguishing characteristics. This species is characterized by having thirty to forty costellae per 10 mm at a surface measurement of 25 mm from the ventral beak, by its relatively narrow, gibbous ventral umbo, and by its moderately thick body cavity.

Comparisons. This new *Ovatia* can be readily differentiated from *Ovatia laevicosta* (White), another Lower Mississippian species from the midcontinent, by its finer costellae, thicker body cavity, and large, narrow, gibbous ventral umbonal region. *Ovatia laevicosta* has an exceptionally thin body cavity, a much less inflated and broader umbonal region, and about twenty to twenty-seven costellae per centimetre.

Ovatia belliplicata (Branson) from the Chouteau Limestone of Missouri, differs substantially from *O. prolata* n. sp. by its much flatter profile, smaller umbonal region, and unusual ornamentation.

The Upper Mississippian species *Ovatia ovata* (Hall), *O. pileiformis* (McChesney), and *O. elongata* Muir-Wood and Cooper are similar to *O. prolata* n. sp. in size, outline, and profile, but can be distinguished by their coarser costellae, more numerous and better defined spine bases, and stronger lateral rugae that may be weakly expressed on the venter.

Ovatia croneisi (Branson), from the Amsden Formation of Wyoming, has fine costellae similar in number to those of *O. prolata* but is easily distinguished by its broader outline, and wider hinge line.

Distribution. This species enjoys wide geographic distribution, ranges throughout the *Calvustrigis rutherfordi* Zone of both facies and well into the *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone in the Bow River valley region. In the Jasper area, it is also found in the lower Rundle Group at unzoned horizons. *Ovatia prolata* has been identified in collections from the following GSC localities: 36760, 36777, 37131, 40263, 49688, 49692, 49695, 49698, 49706, 49707, 49721, 49723, 49727, 49728, 49730, 49731, 49733, 49740, 49754, 62087, 66038, 66113, 66331, 66332, 68448, 68455, 68457, 68487, 68522, 69549, 69554, 74866, 74931, C-4129, C-4130, C-7383, C-11787, C-57470, C-57471, C-86542, C-86543 and C-86545.

Productacean gen. et sp. indet.

Plate 7, figures 22-26

Remarks. This incomplete specimen, lacking the trail, from GSC locality 16288, is a medium sized, weakly geniculate shell with a moderately rugose visceral disc, and a few elongate spine ridges that grade into moderately fine, discontinuous costae anteriorly on the pedicle valve. The outline of the preseved portion of the shell is transversely subquadrate. The brachial valve is moderately concave, with convex flexures defining the ears. The body cavity is only about 4 mm thick, but the specimen is slightly crushed and the valves are not tightly articulated posteriorly. The brachial valve ornament consists of weak rugae and scattered elongate to rounded dimples.

The concave brachial valve, thin body cavity, and rugose weakly costate ornament suggest that this specimen

might belong either to the Overtoniidae or the Leioproductidae. Although convincing familial characters are lacking in this specimen it certainly cannot be assigned to any of the other productids discussed in this paper.

Order RHYNCHONELLIDA Kuhn, 1949

Superfamily RHYNCHONELLACEA Gray, 1848

Family TRIGONIRHYNCHIIDAE McLaren, 1965

Genus *Hemiplethorhynchus* von Peetz, 1898

Hemiplethorhynchus allani (Warren), 1932

Plate 13, figures 13-37; Figures 5, 6

1932 *Camarotoechia allani* Warren, in Allan, Warren and Rutherford, p. 244, Pl. 2, figs. 12-15.

1952 *Camarotoechia allani* Warren. Brown, p. 88.

1952 *Greenockia snaringensis* Brown, Pl. 4, fig. 2b (not 2a, 2c-f).

1961 *Camarotoechia allani* Warren. Nelson, Pl. 2, figs. 8-14.

Description. Smaller than average for genus, unequally biconvex, brachial valve more inflated than pedicle valve; subovate to subtrigonal in outline; greatest width at or slightly anterior to mid-length; lateral profile lenticular to subtrigonal; anterior commissure uniplicate, serrate; fold and sulcus moderately well developed, of medium width; lateral margins straight, cardinal margins slightly compressed, deflected dorsally; both valves multiplicate with eight to fourteen, usually ten to thirteen, subangular, straight plicae on the lateral slopes, and four to eight, usually five to seven, less angular plicae in the sulcus; irregularly spaced growth varices occasionally preserved; growth lines not observed.

Pedicle valve moderately inflated, with weakly to moderately convex lateral slopes, most convex in umbonal region; maximum thickness attained near or anterior to mid-length of valve; umbonal region slightly swollen in some specimens; beak strongly curved, acute, erect to suberect; foramen very small, ovate; beak ridges subangular, moderately produced, curving laterally and defining small low concave palintropes; delthyrium partially occluded by thin narrow deltidial plates; sulcus originating anterior to umbonal region, of moderate width, flat bottomed, becoming moderately deep anteriorly, producing a moderate lingual extension at substantially less than right angles to lateral commissure; plicae originating at beak, becoming very fine at cardinal margins; plicae subangular on lateral slopes and commonly less angular or rounded in sulcus; sulcal plicae may be found on both floor and sides of sulcus.

Pedicle valve interior with short slightly divergent dental plates; teeth blade-like and of moderate size; ventral muscle field elongate-ovate, weakly impressed.

Brachial valve more inflated than pedicle valve, almost evenly convex in anterior profile, slightly flattened medially in lateral profile; lateral slopes almost evenly convex; maximum thickness usually attained anterior to mid-length of valve; umbonal region usually not swollen but delimited by small flexures at the cardinal margins; fold well defined, originating in posterior half of valve, rising gradually, flattened, of moderate width; ornament complementary to opposite valve.

Brachial valve interior with short septalium supported posteriorly by stout, short median septum that extends forward about one third of valve length; septalium covered anteriorly by inner hinge plates that fuse to form short, thin connectivium; crural bases attached to medial edges of narrow, thick, outer hinge plates, which in turn are fused to high, stout, inner socket ridges; crura short, hook-shaped in section, curving slightly ventrally; dorsal adductor scars narrow, elongate, with no impression.

Dimensions (mm).

Specimen	Length	Width	Thickness
UA Cb 300	+17.4	17.7	12.3
GSC 9188	17.9	17.5	11.0
GSC 63285	15.4	14.0	11.9
GSC 63286	12.4	12.6	9.7
GSC 63287	11.4	12.3	7.9
GSC 63288	12.0	11.5	7.9

Type material. Lectotype (designated here) University of Alberta Cb 300, illustrated by Warren, 1932, Pl. 2, fig. 12. Paralectotypes University of Alberta Cb 298, Cb 299, and Cb 301 (the last apparently lost or misplaced).

Distinguishing characteristics. Hemiplethorhynchus allani (Warren) is characterized by its subovate to subtrigonal outline, well defined beak, relatively coarse ribbing with eight to fifteen plicae, usually ten to fourteen on the lateral slopes, and five to eight, occasionally four, in the sulcus.

Comparisons. In the Banff Formation *Hemiplethorhynchus allani* (Warren) is similar to and can be confused with *Hemiplethorhynchus snaringensis* (Brown). These species share nearly the same geographic and stratigraphic distribution. Large, finely ribbed *H. allani* may appear similar to some coarse ribbed individuals of *H. snaringensis*, although well preserved individuals of the latter are easily distinguished by false palintropes on each side of the ventral beak. Average specimens of *H. snaringensis* can readily be distinguished by their finer, more numerous plicae on both the lateral slopes and fold and sulcus, and by their broader fold and sulcus and generally larger size.

The syntype selected here as lectotype (Pl. 13, figs. 14-17) is in fact a very large individual with numerous plicae, possibly fifteen, on the lateral slopes and eight in the sulcus, well within the range of variation of *H. snaringensis* (Brown). This specimen is, therefore, actually a morphological extreme in this author's interpretation of *H. allani.*

The lectotype is the only specimen of *H. allani* examined that possibly has as many as fifteen plicae per lateral slope, but it is also the best preserved of the syntypes designated by Warren and is clearly the most satisfactory type specimen for determination of most exterior morphological details.

A few, coarsely ribbed specimens of *H. snaringensis* (Brown) have as few as sixteen plicae on the lateral slopes and as few as seven plicae in the ventral sulcus. If the diagnostic false palintropes cannot be determined and an accurate count of the plicae is not possible, such specimens might be difficult to differentiate from *H. allani.* One of Brown's paratypes (GSC 9188, Pl. 13, figs. 18-21) of *H.*

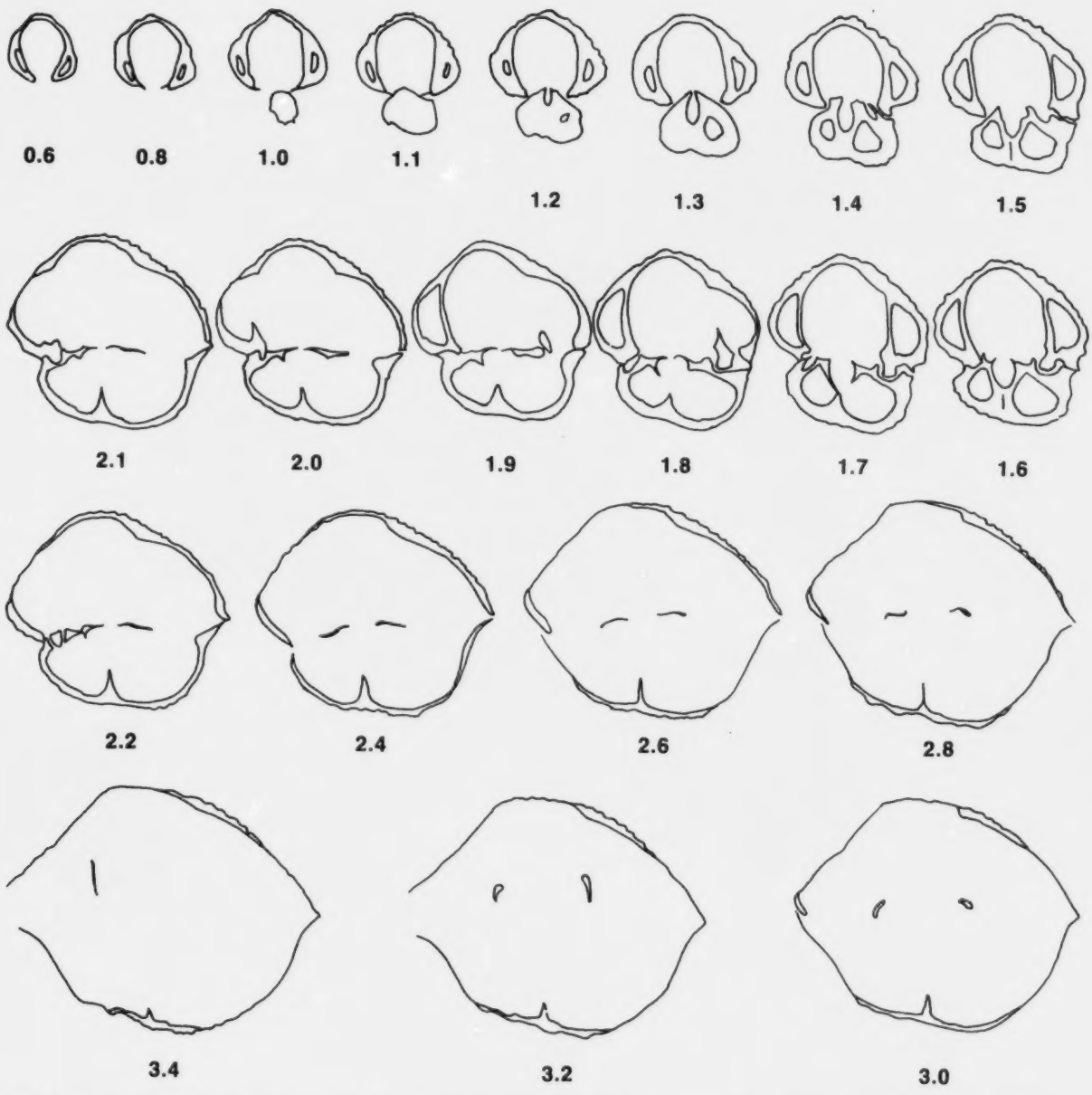

Figure 5. *Transverse serial sections (x6) of* ***Hemiplethorhynchus allani*** *(Warren), GSC 63289, from GSC locality 49753. The measurements refer to millimetres from the ventral beak.*

snaringensis appears to be such a specimen. It has only six plicae in the sulcus and a maximum of thirteen on the lateral slopes. Because it is completely spalled, the false palintropes, if originally present, cannot be recognized. The dimensions are nearly the same as those of the lectotype of *H. allani.* Therefore, this author considers it likely that Brown's paratype (GSC 9188) is actually a large individual of *H. allani.* Few other well preserved specimens, if any, identified as *H. snaringensis* in Brown's extensive Banff collections, are readily confused with *H. allani.*

Camaroteochia allani var. *greenockensis* Brown from the lower Rundle beds of the Jasper Park area is similar to small or medium sized individuals of *Hemiplethorhynchus allani* in most respects, but can be differentiated readily by its more trigonal outline, less inflated valves, and fewer ribs on the lateral slopes. Internal details are very similar.

Other species of the genus *Hemiplethorhynchus* are the type species, *H. fallax* Peetz, and *H. peetzi* (Tolmachoff) from the Tournaisian of the Kuznets Basin of the Soviet Union, and *H. subovatum* Carter from the Gilmore City Limestone of central Iowa. *Hemiplethorhynchus fallax* differs from *H. allani* by its generally larger size, more transverse outline, less well defined ventral beak, and finer, more numerous plicae, which number about forty on each

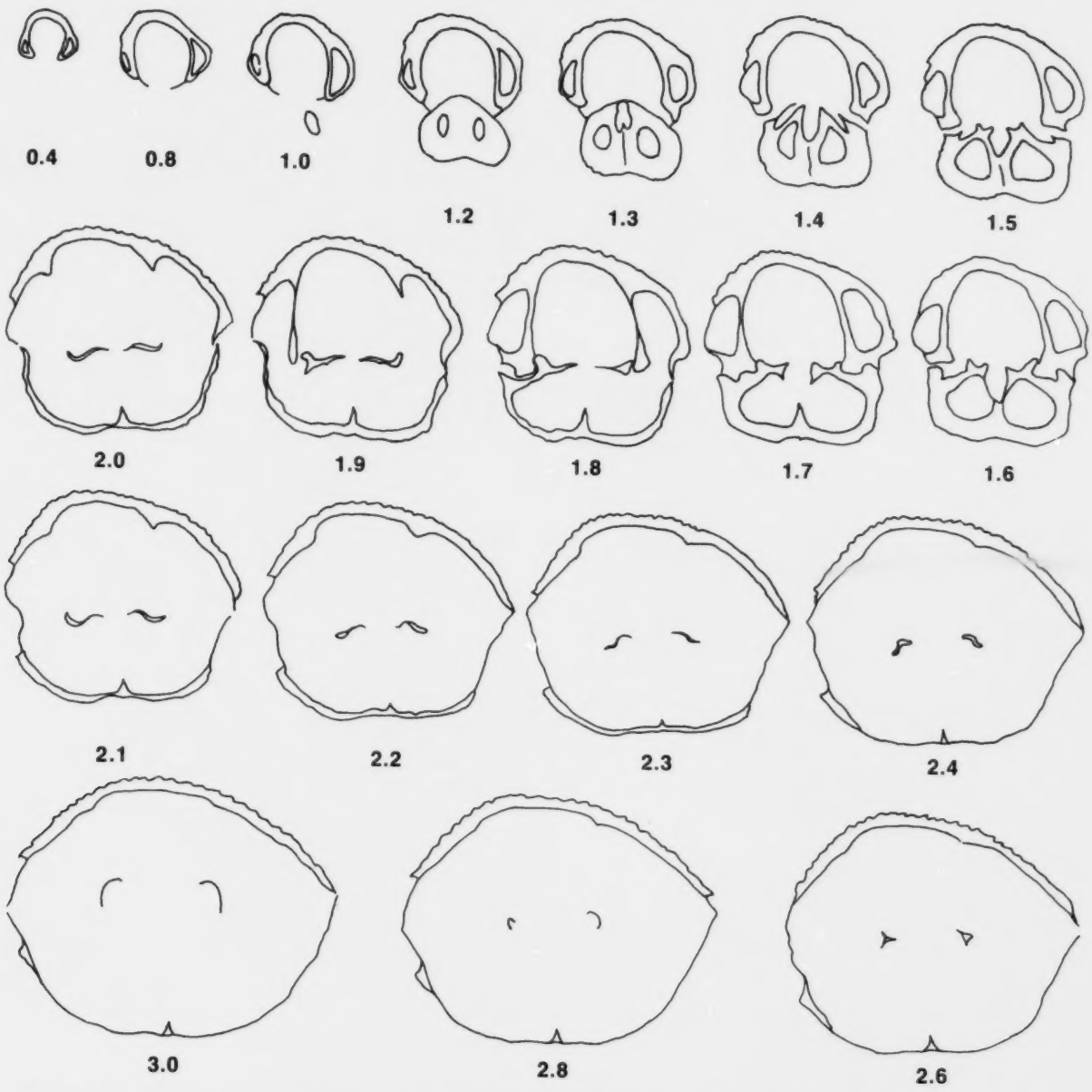

Figure 6. *Transverse serial sections (x7.5) of* ***Hemiplethorhynchus allani*** *(Warren), GSC 63290, from GSC locality 66102. The measurements refer to millimetres from the ventral beak.*

valve. *Hemiplethorhynchus allani* usually has a total of about thirty to thirty-six plicae on each valve. *Hemiplethorhynchus peetzi* (Tolmachoff) is larger and more elongate, with a broad, obtuse umbonal region. *Hemiplethorhynchus subovatum* Carter is smaller, much less inflated, and has fewer plicae than *H. allani*, with three to five in the sulcus and ten to twelve on the flanks.

Distribution. Hemiplethorhynchus allani (Warren) is restricted to the *Calvustrigis rutherfordi* Zone. It is fairly common in the eastern facies, particularly in the Jasper region. In the western facies it has been found only at Mount Rundle, GSC locality 69550. It occurs at the following GSC localities of the eastern facies: 31347, 31349, 36760, 36777, 49690, 49707, 49719, 49722, 49727, 49731, 49736, 49753, 49754, 66102, 68460, 68570 and C-86544.

Hemiplethorhynchus snaringensis (Brown), 1952

Plate 14, figures 17-40

1952 *Greenockia snaringensis* Brown, p. 91-92, Pl. 4, figs. 2a, 2c-f (not 2b).

1961 *Greenockia snaringensis* Brown. Nelson, Pl. 2, figs. 15-16.

1965 *Hemiplethorhynchus snaringensis* (Brown). Sartenaer, p. 1-9, Pl. 2.

1965 *Hemiplethorhynchus snaringensis* (Brown). McLaren, in Williams et al., p. 561, fig. 430: 1e, 1g (not 1f).

Description. Average size for genus, unequally biconvex, brachial valve much more inflated than pedicle valve; subovate, subtrigonal or subpentagonal in outline; moderately transverse to slightly elongate, greatest width usually near or anterior to mid-length; lateral profile subovate to thickly lenticular; anterior commissure uniplicate, serrate; fold and sulcus broad, commonly flattened, moderately well developed in anterior half of shell; lateral margins straight in profile; cardinal margins not ordinarily compressed; both valves multiplicate with about sixteen to nineteen, occasionally twenty, subangular to rounded plicae on each lateral slope and seven to eleven rounded to subangular plicae in sulcus, commonly including several plicae on walls of sulcus; growth lines very closely and irregularly spaced; shell substance impunctate.

Pedicle valve much less inflated than brachial valve, most convex in umbonal region; lateral slopes weakly convex; maximum thickness attained in posterior third of valve; beak pointed, strongly incurved, erect, with small apical foramen; beak ridges sharp, angular, curving laterally to cardinal margins, defining narrow, subparallel, concave palintropes; nonplicate, weakly concave, narrow, triangular "pseudopalintropes" formed by lack of ribbing just anterior to true palintropes; delthyrium partially occluded by narrow, triangular, deltidial plates; sulcus of moderate depth, originating near or slightly posterior to mid-length in large adults, becoming broad and commonly flat bottomed with serrate, linguiform extension anteriorly; plicae on posterior lateral slopes rounded, becoming subangular anteriorly, sulcal plicae tending to be slightly more rounded anteriorly than those of lateral slopes.

Pedicle valve interior with short, concave, diverging dental plates that extend anteriorly to posterior edge of ventral muscle field; teeth wide, spatulate; muscle field deeply impressed, flabellate; diductors large, subtrigonal, enclosing adductors anteriorly; adductors narrow, elongate, subelliptical; ventral adjustors narrow, subelliptical, posteriorly placed at outer edges of muscle field; ventral mantle canal pattern saccate, with large vascula genitalia enclosed by posterolaterally curving vascula media.

Brachial valve moderately to strongly inflated, evenly convex in lateral profile with maximum thickness attained near mid-length; anterior profile also nearly evenly convex, lateral slopes curving evenly to lateral margins; umbonal region not inflated, defined by weakly concave lateral inflections; beak obscured by pedicle valve; fold moderately developed anteriorly, originating at about mid-length in large specimens, incorporating several plicae on fold walls; ornament as on pedicle valve.

Brachial valve interior with small, narrow septalium supported by thick, high, median septum that extends forward about one third to one half of valve length; inner hinge plates medially fused to form connectivium over most of septalium; apical foramen present; outer hinge plates thick, flattened, fused to low inner socket ridges; crural bases fused mainly to outer hinge plates and secondarily to inner hinge plates; crura short, slightly concave on ventral surfaces, arcuate, curving slightly toward pedicle valve; dorsal adductors slightly impressed, anterior pair subtrigonal, elongate; posterior pair narrower and more deeply impressed; mantle canal pattern similar to that of pedicle valve.

Dimensions (mm).

GSC no.	Length	Width	Thickness
9183	19.6	18.7	13.0
63291	21.6	24.0	16.2
63292	21.0	21.6	14.3
63293	17.6	19.4	11.8
63294	18.2	16.4	13.1
63295	16.5	16.7	11.2

Type material. Holotype GSC 9183, GSC locality 49736, Pl. 14, figs. 29-32. Paratypes GSC 9187, 9190, 10009. GSC 9188 is considered most likely to be a specimen of *Hemiplethorhynchus allani* (Warren) and is illustrated in Plate 13, figs. 18-21, with that species.

Distinguishing characteristics. This species is characterized by its large size, ordinarily transverse outline, inflated profile, sixteen to nineteen lateral plicae, seven to eleven sulcal plicae, and the "pseudopalintropes" on the pedicle valve.

Comparisons. In the Banff Formation, brachiopod fauna *Hemiplethorhynchus snaringensis* is similar to *H. allani* (Warren) and *Moorefieldella miettensis* Carter, n. sp. *Hemiplethorhynchus allani* can be distinguished by its smaller size and coarser, more angular plicae with about ten to thirteen plicae on the flanks and about five to seven in the sulcus. Internally, *H. allani* has straight, nearly parallel dental plates, whereas *H. snaringensis* has medially concave, diverging dental plates.

Moorefieldella miettensis differs from *H. snaringensis* by its much smaller size and proportionately finer ribbing with about eighteen to twenty-one rounded costellae on the flanks and ten to fourteen in the sulcus. Internally, it has discrete sinuous inner hinge plates, whereas *H. snaringensis* has virtually a flat connectivium.

Hemiplethorhynchus snaringensis is most similar to *H. fallax* Peetz, the type species, from the Tournaisian of the Kuznets Basin. The former differs from *H. fallax* in being more inflated, with a slightly better defined and more elongate ventral beak, attains its maximum width more anteriorly, and appears to have slightly more numerous ribs on each valve. In addition, *H. fallax* seems to lack the "pseudopalintropes" or nonribbed areas just anterior to the beak ridges, which are found in *H. snaringensis*.

Distribution. Hemiplethorhynchus snaringensis is known only from the eastern facies in the Jasper region. It occurs sparingly in the higher beds of the Banff Formation in this region, is absent in the lower Rundle beds, and reappears in the lowermost Shunda Formation. Specimens from the last unit are more robust than the Banff individuals and may represent a distinct subspecies. *Hemiplethorhynchus snaringensis* has been found at the following GSC localities: 36777, 40263, 49692, 49704, 49736, 49753, 49757, 74861 and 74862.

Genus *Moorefieldella* Girty, 1911

Moorefieldella prisca n. sp.

Plate 14, figures 1-16; Figures 7, 8

Description. Small for genus, subequally biconvex, with longitudinally to transversely subovate outline; greatest

width attained near mid-length; lateral profile lenticular; anterior commissure uniplicate; fold and sulcus moderately well developed; lateral commissure almost straight to slightly sinuous; cardinal margins even or occasionally slightly compressed; both valves multicostellate, with about eighteen to twenty-one, rounded, simple costellae on each lateral slope and about ten to fourteen in the sulcus; coarse, irregularly spaced growth varices present on some specimens; micro-ornament not observed; shell substance impunctate.

Pedicle valve slightly thinner than brachial valve, weakly convex on lateral slopes, most convex in umbonal region; maximum thickness usually attained posterior to mid-length; umbonal region not inflated, beak small, incurved, suberect, not well differentiated from umbo, beak ridges weakly developed, subrounded; palintropes small, triangular, weakly concave; delthyrium partially occluded by narrow triangular deltidial plates; sulcus weakly to well developed, of moderate breadth, flat bottomed or gently concave, usually originating in posterior third of valve; moderate linguiform extension produced; costellae evenly rounded in all growth stages on lateral slopes and in sulcus.

Pedicle valve interior with short slightly diverging dental plates and rounded spatulate teeth; muscle field weakly impressed, subtrigonal, extending forward to about one third of valve length.

Brachial valve moderately inflated, evenly convex in lateral and posterior profile; greatest thickness attained at about mid-length; lateral slopes evenly convex; umbonal region not inflated, evenly convex or occasionally slightly flattened; cardinal margins usually weakly reflexed and weakly concave; fold weakly to moderately well developed but never high, weakly convex anteriorly.

Brachial valve interior with very short, narrow septalium with open end facing anteriorly; median septum stout, low, short, extending about one fourth of valve length; inner socket ridges low and moderately thin; outer hinge plates flat, thin, wide; inner hinge plates discrete, sinuous in transverse section, apparently not fused medially; crural bases fused to medial edges of outer hinge plates and outer edges of inner hinge plates; crura short, broad and sinuous in section posteriorly, becoming stout and subtrigonal in section anteriorly, with high ventrally directed processes; dorsal adductor scars very weakly impressed, guttate.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63296	14.1	13.6	8.2
63297	11.9	13.0	6.6
63298	10.5	10.7	5.5
63299	11.5	9.6	5.9

Type material. Holotype GSC 63296, Pl. 14, figs. 1-4. Paratypes GSC 63297-63299, Pl. 14, figs. 5-16. All are from GSC locality 36755.

Distinguishing characteristics. This species can be differentiated from other species of *Moorefieldella* by its subovate outline, small size, moderate degree of inflation, ten to fourteen sulcal costellae, eighteen to twenty one costellae on the lateral slopes, and the fold and sulcus originating in the posterior third of the valves. Internally, the dorsal median septum is short, low, and stout and the inner hinge plates are discrete and not fused medially.

Comparisons. Hemiplethorhynchus snaringensis (Brown) is the only Banff Formation species that bears any significant degree of similarity to *Moorefieldella prisca.* It can be distinguished by its much larger size and coarser ornamentation.

Moorefieldella eurekensis (Walcott) from the Lower Carboniferous of Nevada and the Moorefield Formation of Arkansas and Oklahoma is very similar to *M. prisca* although it occurs in much younger formations. It differs by its substantially larger size, greater degree of inflation, and the fact that the fold and sulcus originate more anteriorly than in *M. prisca.* Internally, the inner hinge plates fuse and the septum is high and rather thin in *M. eurekensis,* whereas the inner hinge plates are discrete and the septum is low, short, and stout in *M. prisca.*

Moorefieldella davisi Shaw from the Mission Canyon Limestone of Montana is similar to *M. prisca* in size and number of costellae in the sulcus but differs by its globose profile, subpentagonal outline, and having only eleven costellae on the flanks. As the interior of *M. davisi* has not been described, the generic assignment cannot be considered conclusive.

Distribution. Moorefieldella prisca n. sp. is rare in the Banff Formation. GSC locality 36755 has yielded all the types and better specimens, numbering over fifty specimens in all. GSC localities C-4130 and 36760 have yielded smaller numbers of specimens. All of these collections are from the Jasper Park region, *Calvustrigis rutherfordi* Zone. A single specimen from the *Stegacanthia* cf. *S. bowsheri-Marginatia ferriglenensis* Zone at Grotto Mountain in the Bow River valley appears to belong here.

Genus *Macropotamorhynchus* Sartenaer, 1970

Macropotamorhynchus curiosus n. sp.

Plate 16, figures 1-48; Figures 9, 10

Description. Medium size for genus, subequally biconvex, outline highly variable, ranging from transversely subtrigonal or subrounded to longitudinally subovate; greatest width usually near or anterior to mid-length; lateral profile moderately to thickly lenticular; anterior commissure nearly straight to uniplicate, serrate; fold and sulcus weakly to moderately developed, variable in width; cardinal margins slightly compressed in some specimens; lateral margins straight and serrate; both valves strongly ribbed with four to nine, usually five to eight, strong angular plicae on each lateral slope, and two to five, usually three or four, plicae in the sulcus; irregularly spaced growth varices sometimes developed; growth lines irregularly spaced and of variable strength.

Pedicle valve evenly convex in lateral profile or sometimes more strongly convex in the umbonal region; convexity of lateral slopes highly variable, ranging from nearly flat medially with strongly convex margins, to strongly convex medially with almost flat steep margins; maximum depth usually attained near mid-length; umbonal region moderately inflated; beak small, pointed, well defined, suberect, variable in length; foramen tiny, ovate; beak ridges very short, defining small concave palintropes; delthyrium covered with thin deltidial plates; sulcus may be poorly defined, originating in posterior half, never deep, flat bottomed or gently concave anteriorly, variable in width; plicae and interplical furrows angular on both flanks and sulcus. Pedicle valve interior with short, slightly diverging dental plates; muscle field commonly impressed; teeth large and spatulate.

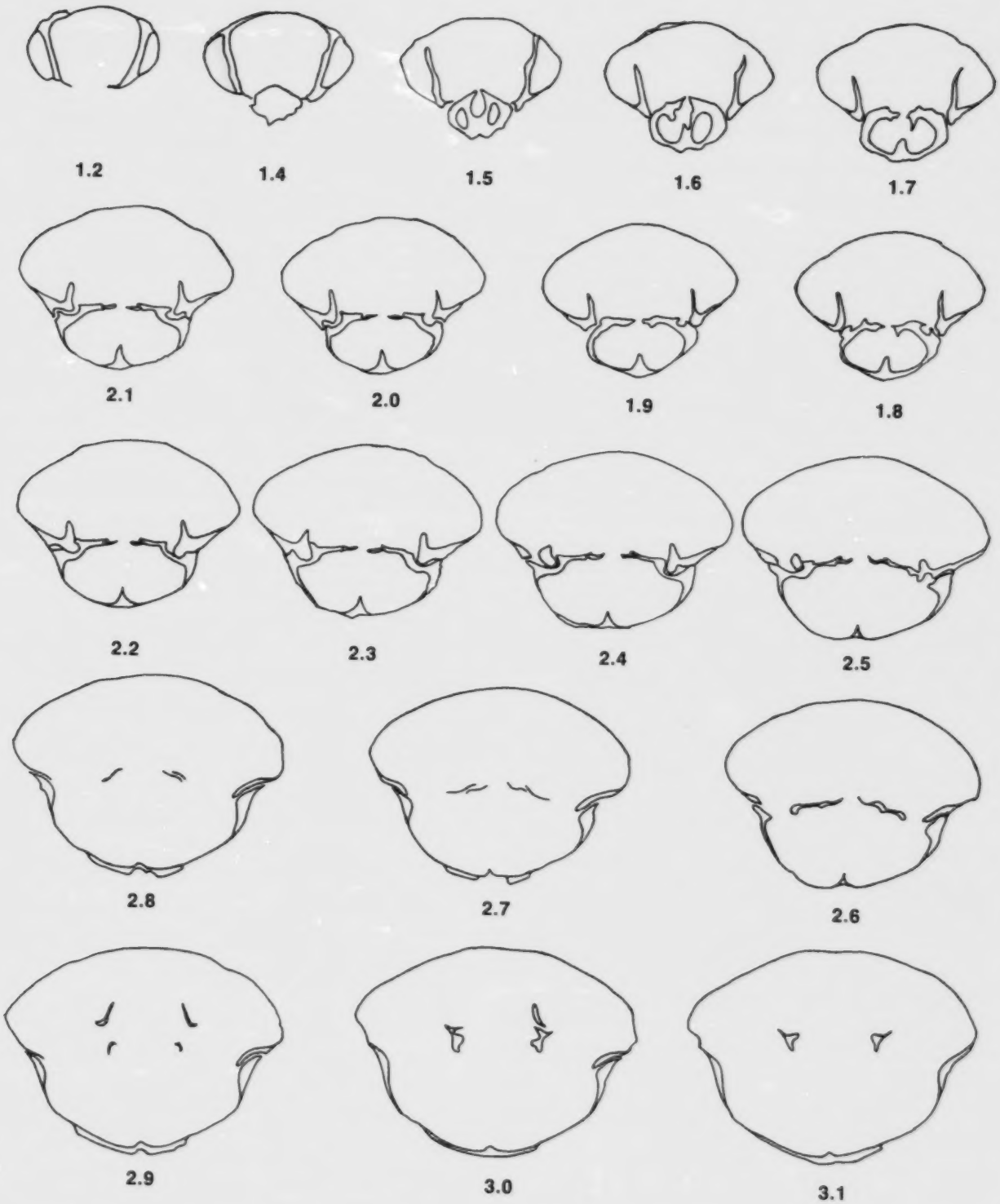

Figure 7. *Transverse serial sections (x6) of* ***Moorefieldella prisca*** *n. sp., GSC 63300, from GSC locality 36755. Measurements are in millimetres from the ventral beak.*

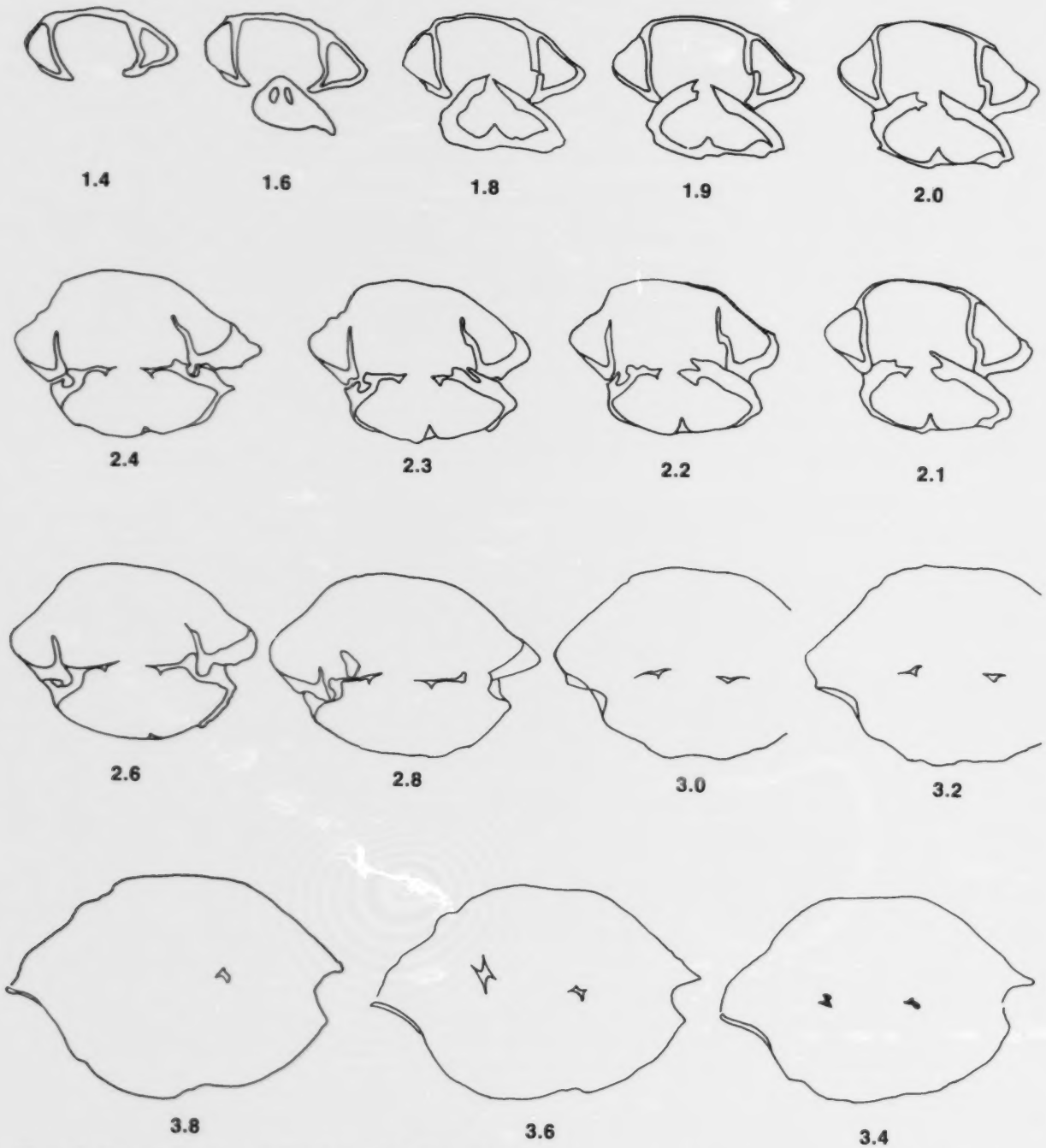

Figure 8. *Transverse serial sections (x6) of* ***Moorefieldella prisca*** *n. sp., GSC 63301, from GSC locality 36755. Measurements are in millimetres from the ventral beak.*

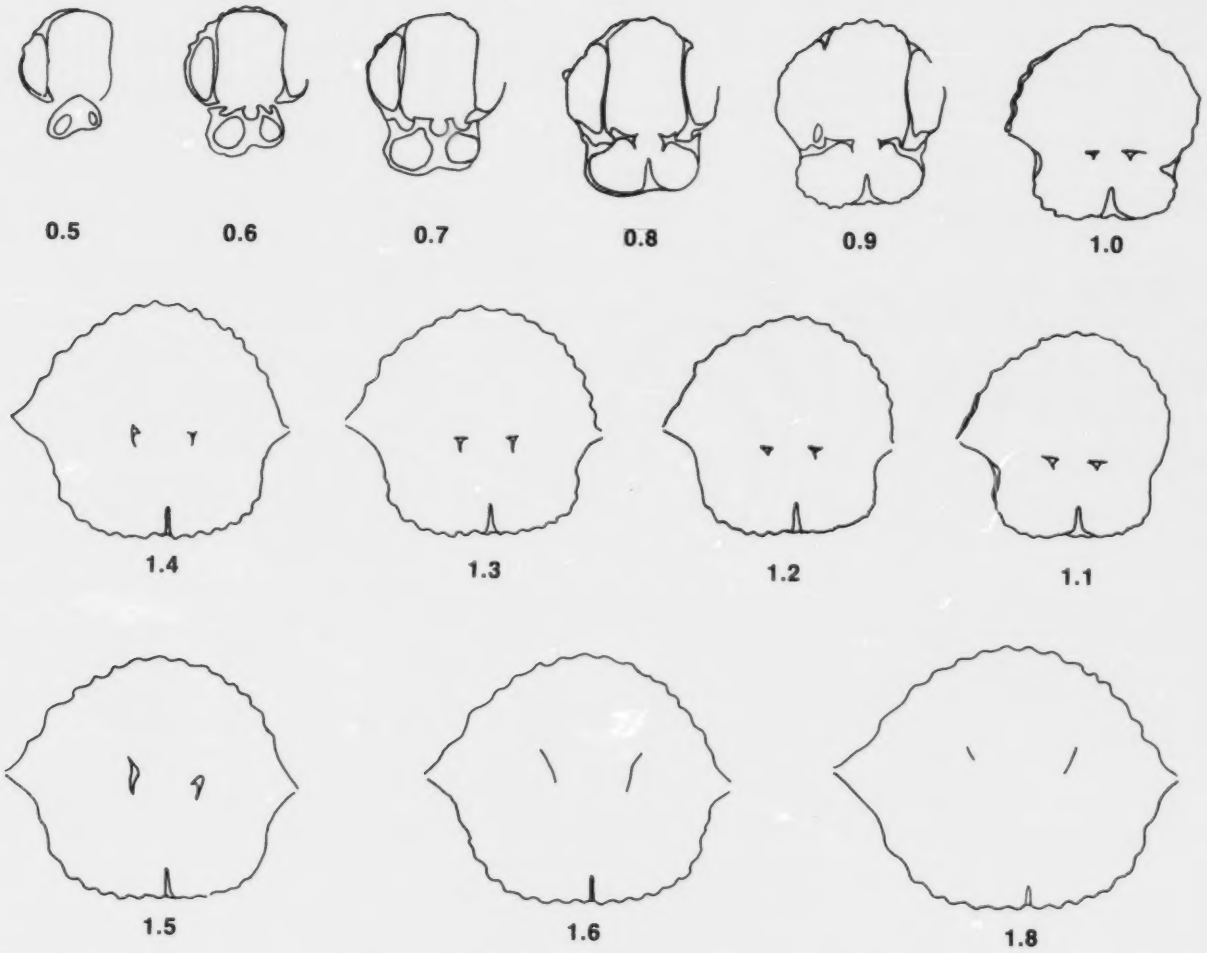

Figure 9. *Transverse serial sections (x9) of* ***Macropotamorhynchus insolitus*** *n. sp., GSC 63311, from GSC locality C-4130. The measurements refer to millimetres from the ventral beak.*

Brachial valve usually slightly thicker than pedicle valve, almost evenly convex, may be slightly flattened medially in profile; maximum depth usually near or slightly anterior to mid-length; convexity of lateral slopes variable as in pedicle valve; umbonal region usually delimited by slight flexures at cardinal margins, not much inflated, commonly with slight medial depression; fold originating at about mid-length, never high, may be obscurely developed, of variable width; ribbing as in pedicle valve.

Brachial valve interior with well developed septalium supported by stout, moderately high median septum that extends forward to about mid-length; inner hinge plates fused anteriorly to form short connectivium leaving substantial apical perforation posteriorly; crural bases fused to both outer and inner hinge plates; crura short, arcuate to straight in section, curving ventrally and diverging anteriorly; outer hinge plates thick and fused to high, prominent, inner socket ridges; sockets deep and large; adductor field indistinct in transverse section.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63313	12.0	12.5	7.2
63314	11.9	9.8	7.7
63315	10.6	10.2	6.8
63316	9.4	10.6	6.5
63317	11.1	10.1	6.7
63318	11.0	9.4	7.9
63319	10.0	9.3	6.1
63320	8.9	9.0	6.0
63321	9.2	8.0	6.0
63322	8.7	7.8	6.1
63323	8.0	7.1	5.6
63324	7.4	5.2	4.0

Type material. Holotype GSC 63313, Pl. 16, figs. 1-4. Paratypes GSC 63314-63324, Pl. 16, figs. 5-48. All are from GSC locality 68573.

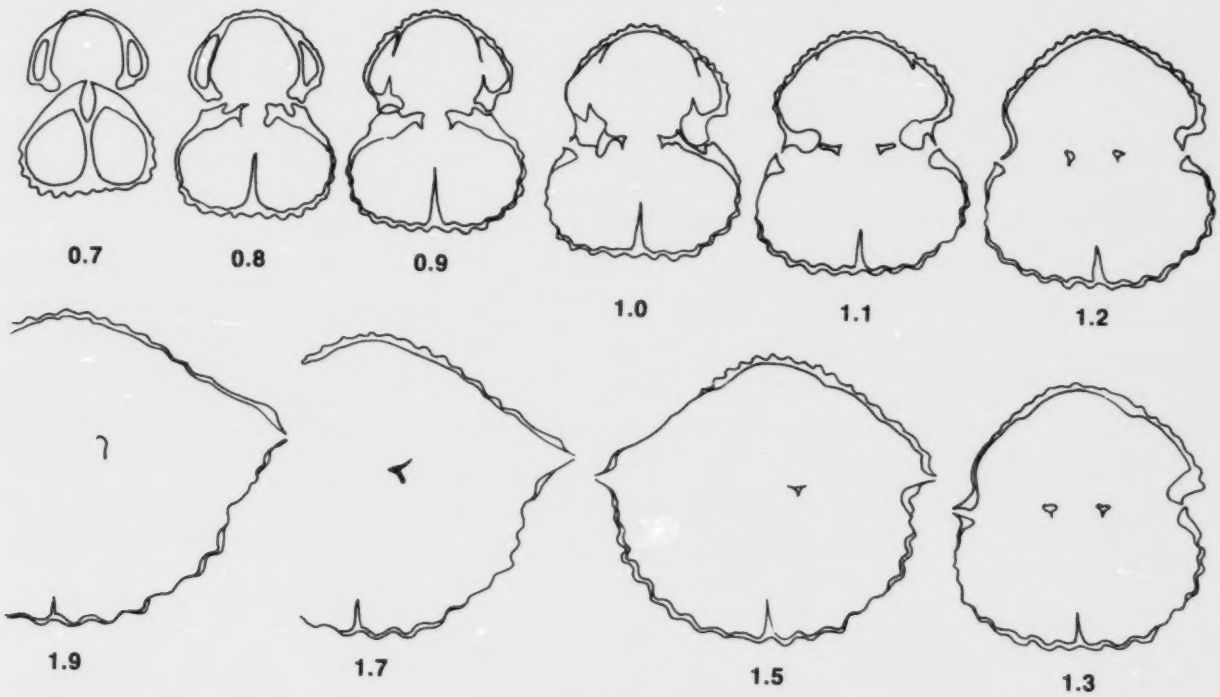

Figure 10. *Transverse serial sections (x9) of* ***Macropotamorhynchus insolitus*** *n. sp., GSC 63312, from GSC locality 49740. The measurements refer to millimetres from the ventral beak.*

Distinguishing characteristics. This species is characterized by its unusually variable shape, outline, and development of fold and sulcus. In addition, it can be distinguished by having three or four, rarely two or five, sulcal plicae, and five to eight, occasionally four or nine, lateral plicae.

Due to its unusual variability in shape, outline, and ornamentation, *Macropotamorhynchus curiosus* n. sp. is not very similar to any previously described species known to the writer. Some rostrate individuals might be compared with *Macropotamorhynchus simplex* (Roberts) from the Tournaisian of the Bonaparte Gulf Basin of Australia. The latter species, however, is more consistent in shape, outline and ornamentation, and almost always has only two plicae in the sulcus and five or six on the lateral slopes. *Macropotamorhynchus curiosus* rarely has only two plicae in the sulcus, usually three or four, and usually has more numerous lateral plicae as well.

Distribution. This species has been found at only one locality, GSC locality 68573, which is from the *Calvustrigis rutherfordi* Zone, eastern facies. This fine collection includes over fifty complete specimens.

Macropotamorhynchus insolitus n. sp.

Plate 15, figures 1-36; Figures 11, 12

Description. Average size for genus; unequally biconvex, slightly transverse to slightly elongate; outline subtrigonal to subovate; greatest width usually at or slightly anterior to mid-length; subtrigonal to lenticular in lateral profile; anterior commissure uniplicate and serrate; fold and sulcus well developed in larger specimens; posterolateral margins commonly slightly compressed; anterolateral margins serrate; both valves covered with strong angular to subangular plicae, with two to four strong angular plicae in the sulcus, three to five corresponding plicae on the fold, and five to eight plicae on the lateral slopes; strong, irregularly spaced growth varices infrequently developed; micro-ornament consisting of very faint, regularly spaced growth lines; shell substance thin and impunctate.

Pedicle valve gently convex posteriorly with well defined narrowly inflated umbonal region; lateral slopes gently convex becoming flattened to weakly concave at the lateral margins; greatest convexity in umbonal region in small specimens, at anterior fold break in large specimens; beak small, narrow, nearly straight to suberect; foramen small, rounded; deltidial plates not observed; beak ridges well developed, subangular, defining small, concave palintropes; sulcus moderately well developed, originating just anterior to umbonal swelling, flat bottomed, of variable breadth, becoming much deeper and flexing strongly dorsally in large specimens, forming a low, flat tongue in larger specimens; plicae subrounded posteriorly, becoming subangular to angular anteriorly, originating at beak.

Pedicle valve interior with short slender slightly divergent dental plates; teeth small, obtusely blade-like; ventral muscle field obscure in transverse section.

Brachial valve much more inflated than pedicle valve, evenly convex to most convex posteriorly, lateral slopes curving evenly or sharply to lateral margins; maximum depth usually attained from mid-length to anterior third of shell; umbonal region flattened, with shallow medial depression; umbonal shoulders flexed ventrally forming compressed cardinal margins; fold originating in posterior half of shell, rising slightly in smaller specimens, rising much higher in large specimens; ornament similar and complementary to that of pedicle valve.

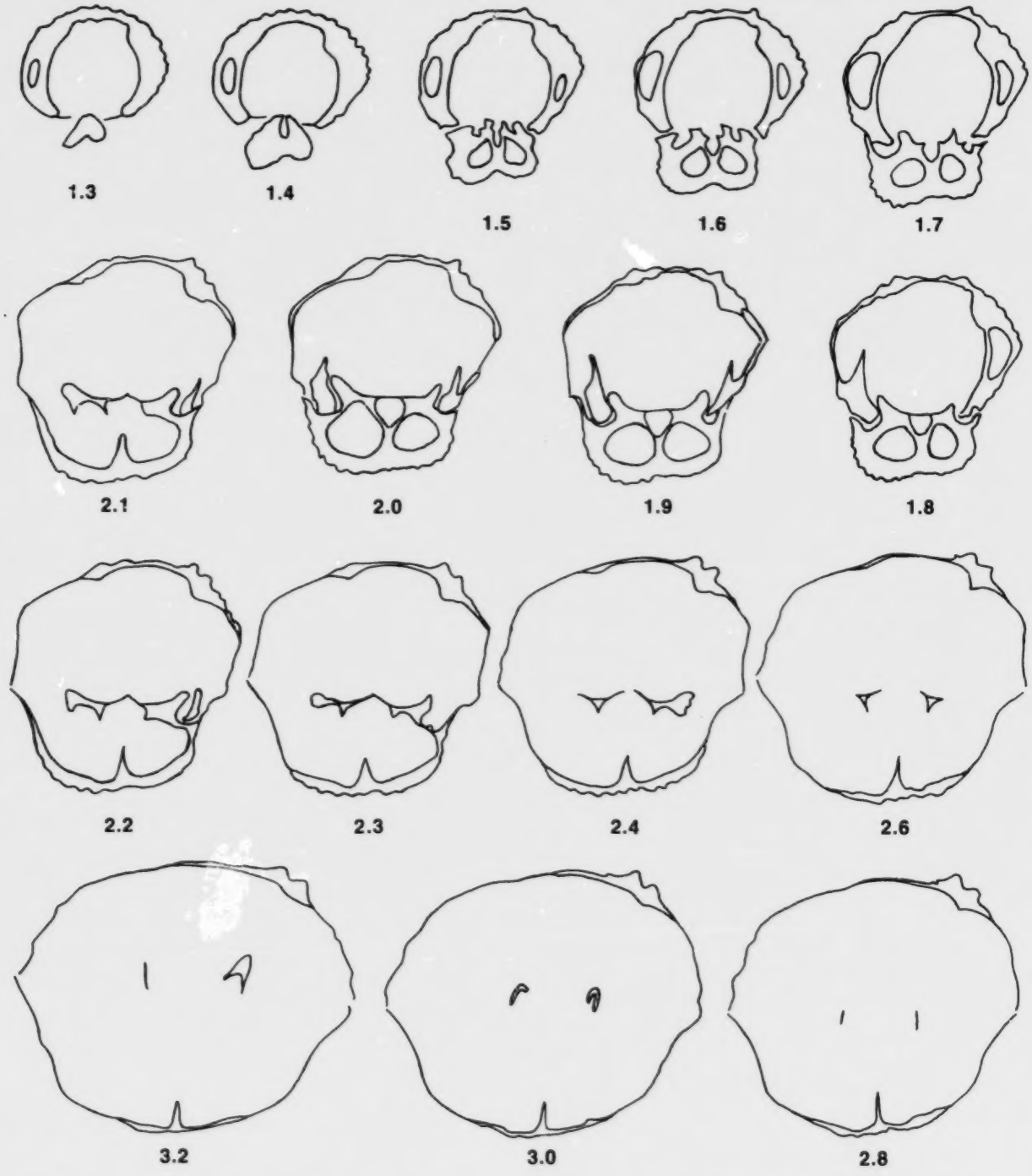

Figure 11. *Transverse serial sections (x9) of* ***Macropotamorhynchus curiosus*** *n. sp., GSC 63325, from GSC locality 68573. The measurements refer to millimetres from the ventral beak.*

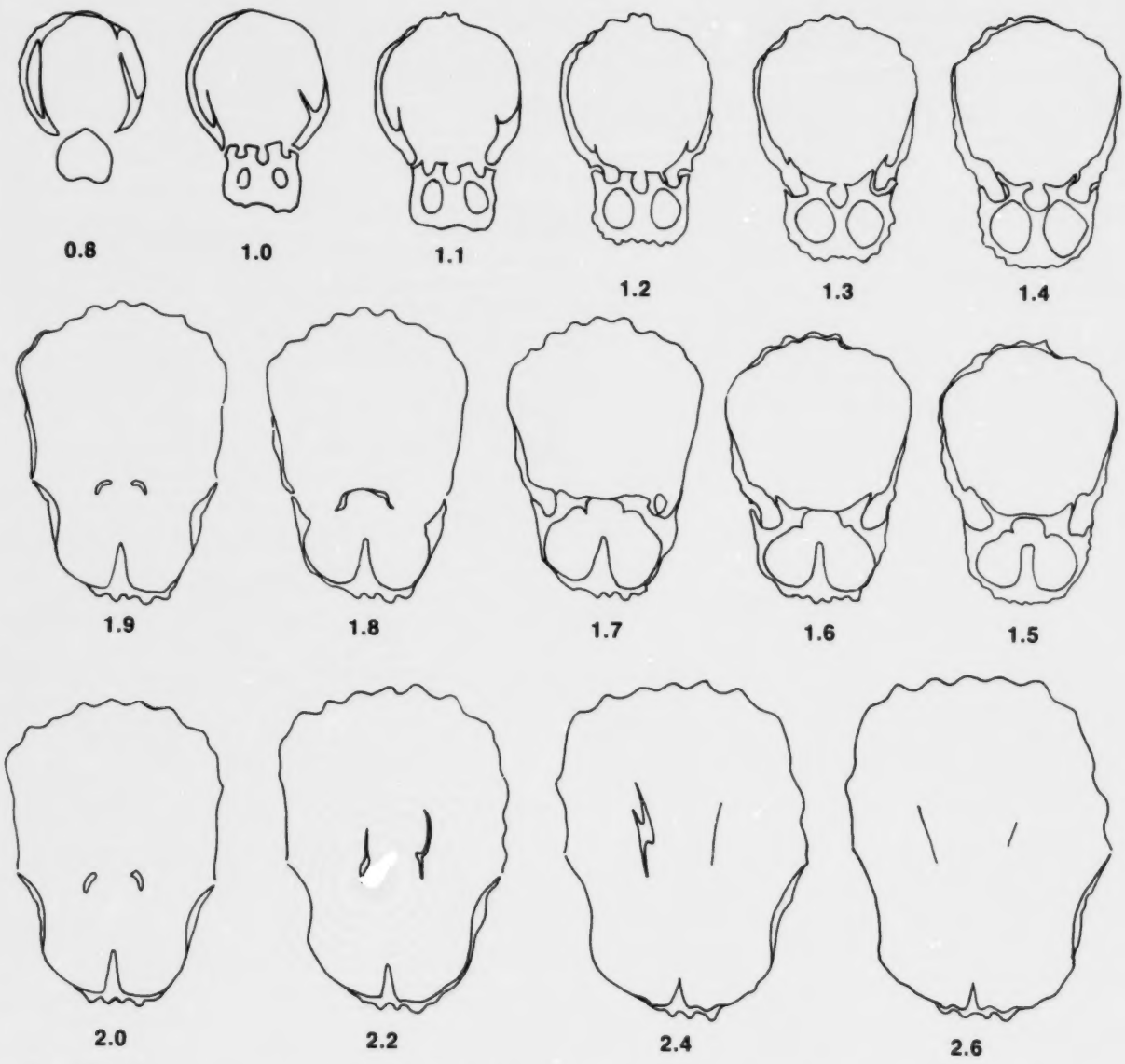

Figure 12. *Transverse serial sections (x9) of* ***Macropotamorhynchus curiosus*** *n. sp., GSC 63326, from GSC locality 68573. The measurements refer to millimetres from the ventral beak.*

Brachial valve interior with short, open septalium upported by moderately high, slender median septum that xtends forward about one third to one half of valve length; onnectivium or inner hinge plate not present in sectioned ecimens; outer hinge plates moderately wide, flat, attached o low, rounded inner socket ridges; crura short, united with uter hinge plates posteriorly, forming broad, flattened rofile posteriorly, becoming triangularly rod-like in middle ortion, then vertically crescentic or blade-like anteriorly, sually curving slightly ventrally; dorsal muscle field obscure n transverse section.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63302	9.4	9.1	5.9
63303	7.8	8.9	5.0
63304	8.4	9.6	5.8
63305	6.8	7.4	4.1
63306	6.6	7.0	4.1
63307	7.5	8.0	4.7
63308	6.1	5.7	3.4
63309	5.9	5.5	4.3
63310	5.5	5.4	3.3

Type material. Holotype GSC 63302, Pl. 15, figs. 1-4, from GSC locality C-4130. Paratypes GSC 63303-63310, Pl. 15, figs. 5-36, from GSC localities C-4130 (GSC 63303), 49707 (GSC 63304-6) and 49692 (GSC 63307-10).

Distinguishing characteristics. This species is characterized by two to four sulcal plicae, five to eight lateral plicae, subequal length and width, compressed cardinal margins, strong subangular beak ridges, and narrow, nearly straight to suberect beak.

Comparisons. *"Camarotoechia" chouteauensis* Weller, *"C." tuta* (Miller), *"C". tidwellae* Shaw, and *"C". herrickana* Girty are North American species that are similar to *Macropotamorhynchus insolitus* n. sp.

"Camarotoechia" chouteauensis Weller from the Chouteau Limestone of Missouri, differs by its larger size, more inflated profile, and rarely, if ever, has two plicae in the sulcus. *"Camarotoechia" tuta* (Miller), from the Lake Valley Limestone of New Mexico, differs by its more inflated profile, more rounded plicae, and more consistant rib formula, most specimens have four plicae in the sulcus and six or seven on the lateral slopes. *"Camarotoechia" tidwellae* Shaw from the Madison Limestone of Montana differs in the same manner as *"C". tuta*, with which it may be synonymous. *"Camarotoechia" herrickana* Girty is known to the author only from Girty's description and types (1899, p. 539, Pl. 69, fig. 2a-e). This species appears to be larger and more transverse than *Macropotamorhynchus insolitus*, with a wider fold and sulcus and an inconspicuous ventral beak.

Other species that show morphologic similarity to *Macropotamorhynchus insolitus* n. sp. are *"Camarotoechia" biplex* (Tolmachoff) from the Tournaisian of the Kuznets Basin, *Macropotamorhynchus septimus* (Veevers), *M. simplex* (Roberts), and *M. amnicus* (Veevers) from the Tournaisian of the Bonaparte Gulf Basin of Australia, and *Camarotoechia mitcheldeanensis* Vaughan from the Tournaisian of England.

"Camarotoechia" biplex Tolmachoff may be closely related to *M. insolitus* but differs in having one to three (rarely four) plicae in the sulcus, and seven to nine lateral plicae. *Macropotamorhynchus insolitus* has two to four sulcal plicae, never one, and five to eight lateral plicae. According to Sokolskaya (1963, p. 241), *"C". biplex* is always wider than long, whereas *M. insolitus* is commonly approximately equidimensional or even slightly longer than wide.

Macropotamorhynchus septimus (Veevers) differs by its more rounded outline, more weakly developed fold and sulcus, less well defined ventral beak, and more numerous lateral plicae. *Macropotamorhynchus amnicus* (Veevers) is much longer than *M. insolitus*, has a deeper, narrower sulcus, usually with only two plicae, and has more numerous lateral plicae. *Macropotamorhynchus simplex* (Roberts) is more rostrate than *M. insolitus* with a narrow, elongate beak. It has coarser plicae and nearly always has only two plicae in the sulcus.

"Camarotoechia" mitcheldeanensis Vaughan can be distinguished from *M. insolitus* by its more consistently transverse outline and coarser plicae. It usually has two plicae in the sulcus, rarely three, with only five or six plicae on the lateral slopes.

Distribution. This highly variable little rhynchonellid is the most common representative of this order in the Banff Formation. It occurs at many localities in both facies and ranges from the lowest fossiliferous beds of the *Calvustrigis rutherfordi* Zone into the *Avonia minnewankensis-Marginatia burlingtonensis* Zone at Lake Minnewanka. It occurs at the following GSC localities: 36760, 37131, 49692, 49695, 49704, 49705, 49706, 49707, 49709, 49710, 49719, 49723, 49727, 49728, 49731, 49734, 49735, 49740, 49741, 49751, 49753, 49754, 49756, 49757, 62101, 66102, 66112, 68448, 68451, 68455, 68459, 68516, 68519, 68522, 68524, 69549, 69550, 69562, 73521, 74858, 74859, 74860, 74931, C-4130, C-7388, C-11787, C-28282, C-57468, C-57471, C-86543 and C-86545.

Family PUGNACIDAE Rzhonsnitskaya, 1956

Genus *Shumardella* Weller, 1910

Shumardella pygmaea n. sp.

Plate 17, figures 1-44; Figure 13

1961 *Shumardella* sp. cf. *S. missouriensis* (Shumard). Nelson, Pl. 2, figs. 17, 18.

Description. Smaller than average for genus, unequally biconvex, transversely trigonal to subovate in outline with greatest width anterior to mid-length; lateral profile subtrigonal to subovate; anterior commissure uniplicate; serrate; fold low posteriorly, becoming high anteriorly in large specimens; sulcus broad, of moderate depth, with medium to large dorsally deflected tongue; lateral margins serrate, cardinal margins straight and distinctly compressed; sulcus with one (32%) or more commonly, two (68%) coarse, rounded to subangular plicae, fold with two or three; flanks with two, or occasionally three, rounded to subangular plicae; growth varices coarse; irregularly spaced capillae of variable amplitude; impunctate.

Pedicle valve shallow, gently convex posteriorly and on lateral slopes; umbonal region low; beak tiny, short, nearly straight, forming very wide angle with cardinal margins; beak ridges rounded and inconspicuous; delthyrium obscured by dorsal umbo, deltidial plates not observed; sulcus shallow posteriorly, originating in posterior third of valve, becoming broader and deeper anteriorly, forming emarginate outline in larger specimens; plicae originating in umbonal region anterior to beak, remaining low and rounded to about mid-length, rising rapidly anteriorly, becoming strong and often subangular. Pedicle valve interior with short, slender, slightly diverging dental plates; teeth small; muscle field obscure in transverse section.

Brachial valve much more inflated than pedicle valve, becoming almost evenly convex in lateral profile in the largest specimens; maximum depth usually attained anteriorly; lateral slopes dropping steeply to lateral margins, umbonal region moderately convex, posteromedian portion of umbo slightly depressed; fold originating in umbonal region, becoming high anteriorly with rounded or flattened serrated anterior profile; lateral plicae weaker than those of fold, obscure in small specimens.

Brachial valve interior with very short septalium supported by low, short median septum that extends forward only about one fourth to one third of valve length; septalium open anteriorly, lying essentially on inner surface of dorsal beak; outer hinge plates lying in plane of lateral commissure, attached to medial surfaces of inner socket ridges; crural bases directed dorsally, slightly arcuate; crura of moderate length, hook shaped in section posteriorly, becoming arcuate then blade-like anteriorly in section and curving ventrally; muscle field obscure in section.

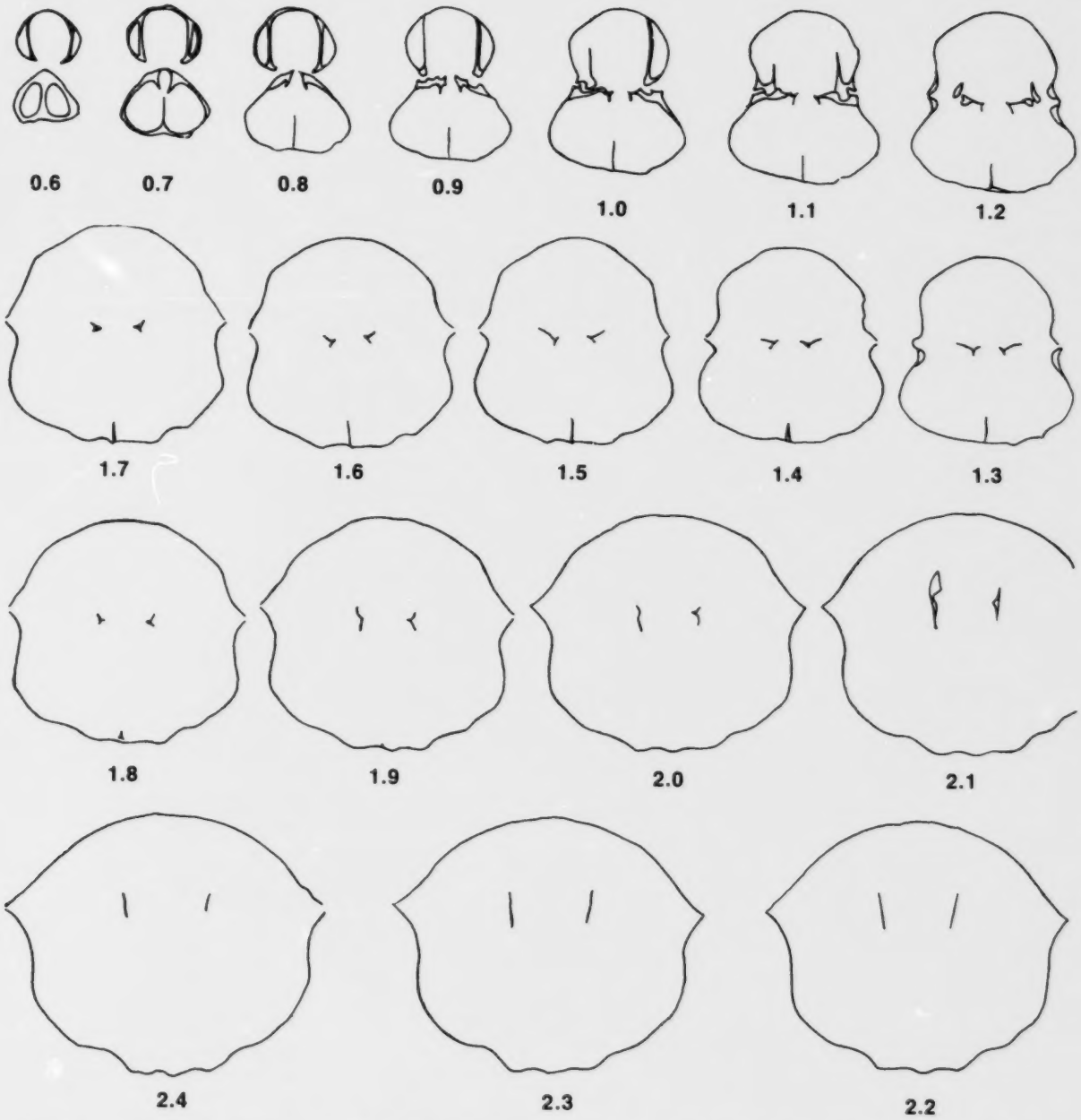

Figure 13. *Transverse serial sections (x6) of* **Shumardella pygmaea** *n. sp., GSC 63337, from GSC locality C-7383. The measurements refer to millimetres from the ventral beak.*

Dimensions (mm).

Specimen	Length	Width	Thickness
UA Cb 360	12.7	13.7	12.1
63327	11.5	14.7	7.3
63328	9.5	13.1	8.4
63329	9.7	11.9	7.0
63330	9.4	10.6	8.2
63331	9.0	10.0	6.1
63332	8.1	9.8	4.9
63333	8.2	9.7	6.0
63334	6.7	8.1	4.2
63335	5.7	6.7	2.3
63336	4.3	4.5	1.8

Type material. Holotype GSC 63328, Pl. 17, figs. 9-12, from GSC locality C-7383. Paratypes: University of Alberta Cb 360, Pl. 17, figs. 1-4; GSC 63327, 63329-63336, Pl. 17, figs. 5-8, 13-44. The GSC paratypes are all from GSC locality C-7383.

Distinguishing characteristics. This new species is characterized by its transverse outline, one or two plicae in the sulcus, compressed cardinal margins, and small size.

Comparisons. This Banff species is similar to *Shumardella missouriensis* (Shumard) from the Chouteau Limestone of Missouri. The latter is readily distinguished by its larger size, more elongate triangular outline, beak ridges, and lack of compressed cardinal margins. Additionally, *S. missouriensis* usually possesses two or three plicae in the sulcus, whereas *S. pygmaea* has one or two plicae in the sulcus.

The plicate flanks serve to distinguish *S. pygmaea* from smooth-flanked species, such as *Shumardella obsolescens* Weller and *"Leiorhynchus" greenianum* (Ulrich).

Distribution. Nelson's (1961) large specimen (University of Alberta Cb 360) is from the middle Banff of the Dormer River area, Alberta. A large collection of complete specimens from GSC locality C-7383, Mount Becker, British Columbia is from the same zone. In the Jasper area, GSC localities 49719 and 49692 have produced specimens of this species as well. All of these localities occur within the eastern facies, *Calvustrigis rutherfordi* Zone.

Genus *Ningbingella* Roberts, 1971

Ningbingella? cf. *Rhynchonella boonensis* Shumard, 1855

Plate 17, figures 45-48

1855 *Rhynchonella boonensis* Shumard, p. 205, Pl. C, fig. 6a-b.

Remarks. Three nearly complete, medium sized rhynchonellid specimens from an unzoned horizon of the Banff Formation were collected by De Wit at Mount Rundle. All three specimens are partially silicified and somewhat crushed with poorly preserved exteriors. Nevertheless, it is possible to determine enough morphological details to compare these specimens with *Rhynchonella boonensis* Shumard, a species of early Osagean age in the midcontinent.

All three specimens appear to have three plicae in the ventral sulcus with some indication of one or two weak plicae at the margins of the lateral slopes. Internal details are incomplete, but short dental plates and a dorsal septum are readily observed. The best of these specimens (GSC 63358, GSC locality C-86546) illustrated here (Pl. 17, figs. 45-48), appears to be wider and thinner than the other two.

Another collection of this species includes two incomplete shells from the "middle" member at Mount Rundle, GSC locality 69554. Warren (1927) may have referred to this species as ?*Shumardella missouriensis* in his report on the Mount Rundle section.

Family RHYNCHOTETRADIDAE Likharev, 1956

Genus *Axiodeaneia* Clark, 1917

Axiodeaneia usheri (Brown), 1952

Plate 13, figures 1-12; Figure 14

1952 *Rhynchotetra elongata* var. *usheri* Brown, p. 92-93, Pl. 5, fig. 5a-c.

1961 *Rhynchotetra usheri* Brown. Nelson, Pl. 3, figs. 1-4.

1970 *Rhynchotetra usheri* Brown. Bamber and Copeland, Pl. 12, fig. 3.

Description. Medium size for family, longitudinally subovate to subtrigonal in outline, unequally biconvex in small adults to nearly equally biconvex in largest specimens; greatest width attained anterior to mid-length; lateral profile subovate to lenticular in moderately sized specimens, truncated subovate in largest adults, anterior profile subquadrate in large specimens; anterior and lateral commissures rectimarginate, strongly serrate; fold and sulcus lacking; both valves moderately convex medially and on lateral slopes; both valves with nine or ten strong subangular plicae, commonly with a symmetrical arrangement; strong growth varices occasionally developed, irregularly spaced; micro-ornament consisting of radial capillae, twenty-two to twenty-five per 5 mm near anterior margin, and fine, regularly spaced growth lines, producing cancellate effect.

Pedicle valve slightly less convex than brachial valve in large specimens, substantially less convex in small specimens; lateral slopes weakly and evenly convex on venter, bending abruptly at lateral margins, almost at right angles to venter; greatest thickness near mid-length; umbonal region broad, not swollen, beak very small, acute, slightly incurved; foramen tiny, at apex of delthyrium; delthyrium partially closed by narrow deltidial plates; beak ridges subangular, defining weakly concave palintropes; plicae very coarse anteriorly; two medial plicae originating at beak, lateral plicae obscure in umbonal region; smallest lateral plicae very low and weak, but producing good deflections at lateral commissures.

Pedicle valve interior with short, diverging dental plates that follow medial plicae about one quarter to one fifth of valve length; teeth relatively small, spatulate; muscle field not observed in tranverse section.

Brachial valve slightly thicker than pedicle valve and with strong median plication that originates at beak; umbo not swollen but sharply defined by beak ridges, producing concave cardinal areas as in pedicle valve; other features similar to opposite valve.

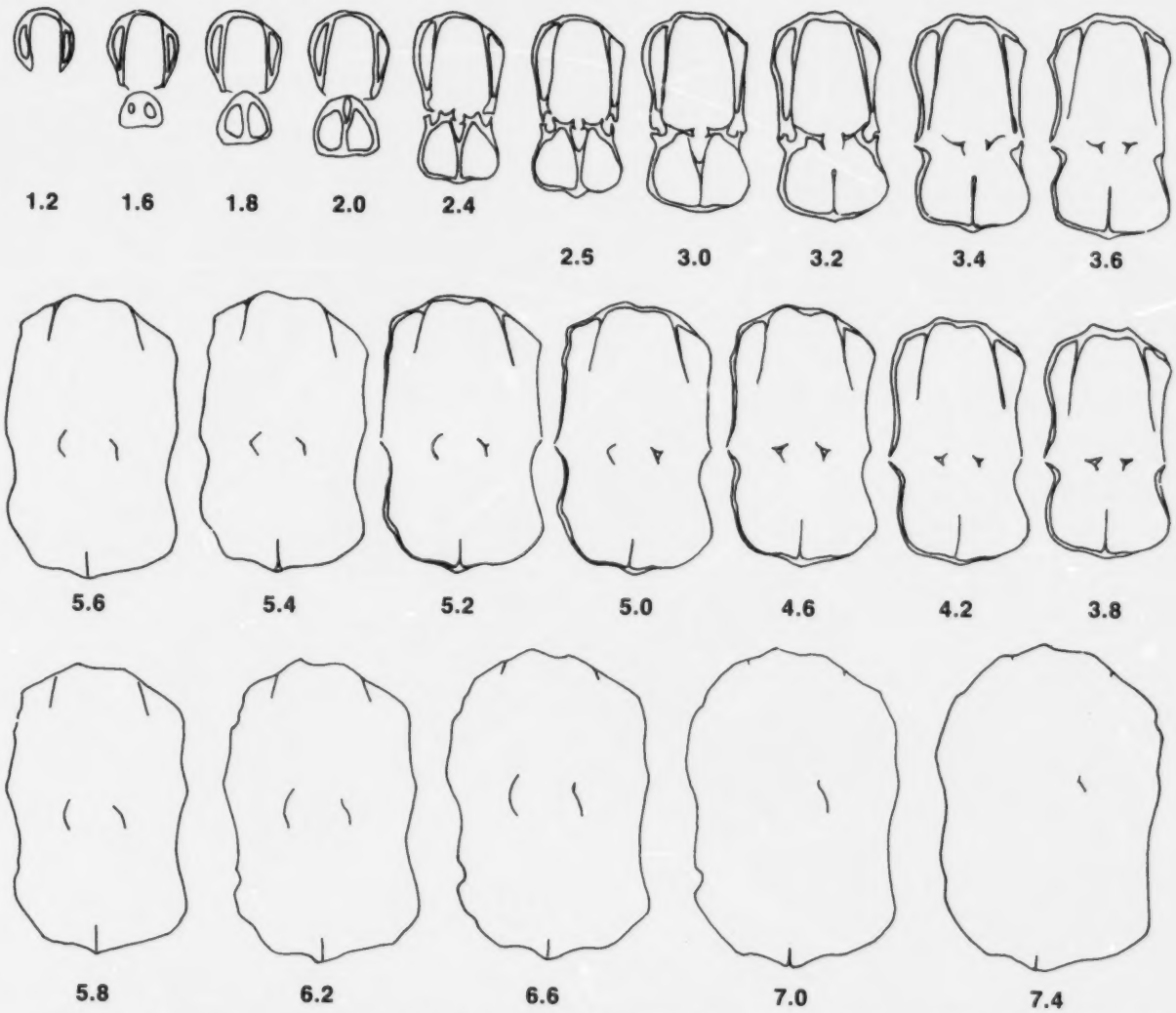

Figure 14. *Transverse serial sections (x3) of* ***Axiodeaneia usheri*** *(Brown), GSC 63339, from GSC locality 20085. The measurements refer to millimetres from the ventral beak.*

Brachial valve interior with short, narrow, deep, open septalium supported by high, narrow median septum that extends forward about one fifth to one fourth of valve length; inner socket ridges narrow, moderately high; outer hinge plates weakly concave on ventral surface, narrow; inner hinge plates absent; crural bases medially concave, arcuate, fused to medial edges of outer hinge plates; crura triangular in section posteriorly, becoming thin, vertically deep, and arcuate anteriorly, remaining in plane of commissure; muscle field not observed in transverse section.

Dimensions (mm).

Specimen	Length	Width	Thickness
UA Cb 361	39.7 (BV)	29.5	23.9
GSC 63339	35.3	25.8	18.4
GSC 9194	32.0 (BV)	21.5	11.3

BV = brachial valve.

Type material. Holotype GSC 9194, Pl. 13, figs. 9-12. Referred specimens: University of Alberta Cb 361, Pl. 13, figs. 1-4; GSC 63339, Pl. 13, figs. 5-8.

Distinguishing characteristics. This species is characterized by its large size, subovate outline, and nine or ten coarse plicae on each valve.

Comparisons. *Axiodeaneia platyplura* Clark is the only other described species of this genus. It can be differentiated from *A. usheri* by its smaller size, more elongate subtrigonal outline, and eight or nine plicae.

Distribution. *Axiodeaneia usheri* (Brown) is a fairly common species in the eastern facies of the Jasper Park region, although good specimens are not very numerous. It is restricted to the *Calvustrigis rutherfordi* Zone in this facies and occurs at the following GSC localities: 20085, 49688, 49690, 49695, 49719, 49730, 66038, 66330, 68522, C-4129, C-4130, C-7388, C-11787, C-86543 and C-86544.

Order ATRYPIDA Moore, 1952

Suborder RETZIIDINA Boucot, Johnson and Staton, 1964

Superfamily RETZIACEA Waagen, 1883

Family RETZIIDAE Waagen, 1883

Genus *Hustedia* Hall and Clarke, 1893

Hustedia circularis (Miller), 1892

Plate 15, figures 37-48

1892 *Retzia circularis* Miller, p. 62, Pl. 9, figs. 32-34.

Description. Small for genus, subequally biconvex, outline longitudinally subovate; greatest width attained near or slightly anterior to mid-length; lateral profile lenticular; anterior commissure rectimarginate, serrate; very weak sulcus present in pedicle valve of some specimens, more commonly lacking; weak medial groove produced in umbonal region of brachial valve of most specimens, absent anteriorly; lateral and cardinal margins straight; ornament consisting of about sixteen to twenty-two simple, strong, rounded, costellae on each valve separated by almost equally wide, rounded grooves, and, rarely, strong but poorly defined growth varices anteriorly; shell substance finely punctate.

Pedicle valve moderately and evenly inflated, most convex posteriorly in umbonal region; lateral slopes more gently convex, curving evenly to anterolateral margins; greatest thickness attained in posterior half of valve; cardinal extremities very slightly compressed; beak moderately elongated; suberect, slightly incurved, perforated by rounded mesothyridid foramen; beak ridges subangular and well defined; palintropes concave, narrow; delthyrium occluded by single concave deltidial plate confluent with palintropes; faint sulcus present near anterior margin of some specimens, usually lacking; costellae higher than wide with rounded crests medially; lateral costellae with subangular crests, becoming progressively lower and curving outward at anterolateral margins. Pedicle valve interior without dental plates; other internal details not observed.

Brachial valve nearly as inflated as pedicle valve, most convex in umbonal region; umbonal region narrow, slightly tumid, defined laterally by concave flexures; lateral slopes evenly convex, curving steeply to anterolateral margins; maximum thickness attained in posterior half of valve; dorsal beak inconspicuous; narrow medial depression or groove originating near beak, becoming obsolete by approximately mid-length; median costella originating in umbonal sulcus or depression; other costellae similar to those of opposite valve.

Brachial valve interior with high hinge plate and medial lingulate process supported by short median septum; crura slender, rod-like, projecting anteroventrally from ventrolateral edges of hinge plate; other details not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness	Number of costellae
63340	5.3	4.9	3.2	18
63341	4.8	4.1	2.7	18
63342	3.0	2.5	1.4	16

Type material. Miller's fourteen syntypes from the Chouteau Limestone of Missouri are in the University of Cincinnati Museum, no. 3992.

Distinguishing characteristics. This species is characterized by its small size, sixteen to twenty-two, usually sixteen to eighteen, costellae per valve, and a weak but distinct median groove or depression in the umbonal region of the brachial valve, which becomes obsolete anteriorly.

Comparisons. The only similar previously described Lower Mississippian *Hustedia* in North America is *H. pygmaea* Rowley (=*Hustedia texana* Girty) from the lower Burlington Limestone of Missouri, the Chappel Limestone of Texas, and the Lodgepole Limestone of Montana.

Hustedia pygmaea is similar in size and outline to *H. circularis*, but differs in having more numerous costellae in most specimens, the pedicle valve usually has a weak sulcus, and the median umbonal groove of the brachial valve usually extends to the anterior margin.

Distribution. This rare, tiny species has been found at only three GSC localities: 62101, 66112, and C-7383. All are from the *Calvustrigis rutherfordi* Zone.

Genus *Eumetria* Hall, 1864

Eumetria osagensis (Swallow), 1860

Plate 18, figures 1-16; Figure 15

1860 *Retzia osagensis* Swallow, p. 653.

1893 *Eumetria? osagensis* (Swallow). Hall and Clarke, p. 227, Pl. 37, figs. 7, 9.

1914 *Eumetria osagensis* (Swallow). Weller, p. 439-441, Pl. 76, fig. 12.

1938 *Eumetria osagensis* (Swallow). Branson, p. 71-72, Pl. 8, figs. 1-5, Pl. 9, fig. 11.

1952 *Eumetria osagensis* (Swallow). Brown, p. 106, Pl. 5, fig. 3.

Description. Medium size for genus, longitudinally subovate in outline, lenticular in profile; subequally biconvex, pedicle valve being slightly thicker than brachial valve; greatest width usually attained slightly anterior to mid-length; anterior commissure rectimarginate or slightly uniplicate; cardinal and lateral margins rounded; ornament consisting of about forty-six to fifty-six, usually about fifty, simple, flattened, fine costae or coarse costellae separated by narrow intercostal grooves, and irregularly spaced growth varices; shell substance very finely and densely punctate, punctae being irregularly arranged in sinuous, concentric rows near growth varices, randomly scattered elsewhere.

Pedicle valve moderately inflated umbonally, most convex and thickest approximately at right angles to hinge line; umbonal region moderately broad, elongate, projecting well beyond brachial valve; beak erect; foramen ovate, epithyridid, slightly labiate; small cardinal area defined by prominent, compressed ridges produced under beak; delthyrium closed by convex symphytium; median anterior half of valve may be slightly flattened, but sulcus not developed; costae of almost uniform width but becoming finer at cardinal extremities; bifurcation very rare, but if present, occurring near medial portion of either valve; ribbing not present on sides of umbo. Pedicle valve interior simple; teeth blade-like, directed posteromedially; muscle field obscure.

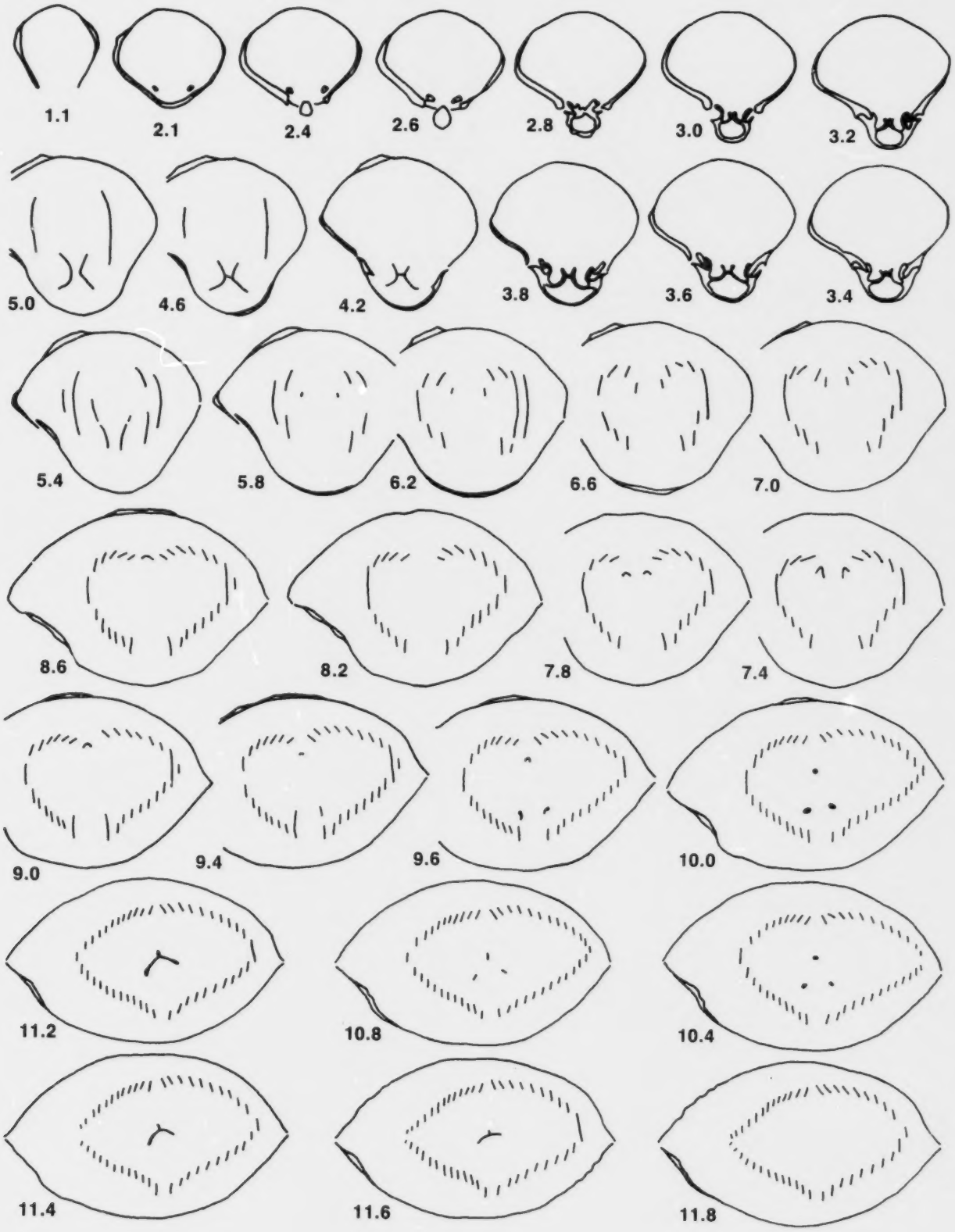

Figure 15. *Transverse serial sections (x3) of* ***Eumetria osagensis*** *(Swallow), GSC 63347, from GSC locality 49736. The measurements refer to millimetres from the ventral beak.*

Brachial valve slightly thinner than opposite valve, most convex umbonally, curving evenly over lateral slopes and dorsum to margins; umbonal region narrow, slightly gibbous, with small beak projecting posteriorly over hinge line, nearly touching ventral beak, defined by concave flexures; anterior profile evenly convex; ribbing similar to opposite valve, lacking only at cardinal extremities.

Brachial valve interior with short hinge plate attached to valve walls below inner socket ridges; lateral flanges of hinge plate extend posteriorly into ventral umbonal region as pointed processes; lateral flanges transverse plate, and plates arising from valve walls project anteriorly, forming crude H in transverse section; crura arise from anteroventral edges of flanges of cardinal plate; spiralia composed of about thirteen whorls; jugum forming moderately broad, transverse, ventrally convex band, directed anteroventrally, with posteroventrally directed medial process that arises between crura, becoming broader and ventrally convex posteriorly, rod-like anteriorly; socket ridges very high, medially convex; sockets deep; adductor field obscure in transverse section, narrow and elongate, narrowly guttate in spalled specimens.

Dimensions (mm).

GSC no.	Length	Width	Thickness	Number of costellae
63343	22.6	20.0	12.5	50-52
63344	20.6	19.1	11.9	48
63345	17.5	13.8	8.7	56
63346	14.8	14.1	8.1	52

Type material. Swallow's original specimens of this species were presumably destroyed by fire many years ago at the University of Missouri. No neotype has been selected.

Distinguishing characteristics. This species can be distinguished by its elongate ventral umbo, epithyridid, labiate foramen and, usually, about fifty ribs on each valve.

Comparisons. There are several other previously described North American species of the genus *Eumetria* of Early Mississippian age. These are *Eumetria polypleura* (Winchell) from the Coldwater Shale of Michigan, *E. swallovi* Moore from the Chouteau Limestone of Missouri, and *E. iowensis* Carter from the Gilmore City Limestone of Iowa.

Eumetria polypleura is a poorly known species, described by Winchell (1862, p. 406) as having about forty ribs on each valve. Otherwise, it may be very similar to *E. osagensis*, which was described two years earlier. *Eumetria swallovi* is known only from a brachial valve. It has very weak depressed costae, lacks small auriculations on the brachial valve, and the anterolateral slopes are flattened, not convex. Branson (1938, p. 73) considers it probable that *E. swallovi* is a synonym of *E. osagensis*. *Eumetria iowensis* is similar in outline and general aspect to *E. osagensis*, but differs in having fewer costae, about thirty-six per valve, and it has a thicker, more inflated profile.

One European species, *Eumetria serpentina* (Koninck), from the Tournaisian of Belgium and the Soviet Union, is similar to *E. osagensis* in outline and nature of the ventral beak. It differs in having about sixty to seventy costae per valve in mature specimens, a less inflated profile, and the brachial valve is much more narrow posteriorly, lacking auriculations.

Distribution. This species is a common and typical element in the *Calvustrigis rutherfordi* assemblage of the eastern facies, occurring at the following GSC localities: 31347, 31350, 36760, 37131, 49688, 49690, 49692, 49695, 49704, 49705, 49706, 49707, 49709, 49723, 49727, 49730, 49736, 49740, 49753, 49756, 49757, 66038, 66115, 68519, 68573, 74931, C-4130, C-7388, C-11787 and C-86545.

A single specimen of *Eumetria* from GSC locality 69565, from the "upper" member of the western facies (probably *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone), may belong to this species.

Suborder ATHYRIDIDINA Boucot, Johnson and Staton, 1964

Superfamily ATHYRIDACEA M'Coy, 1844

Family ATHYRIDIDAE M'Coy, 1844

Subfamily ATHYRIDINAE M'Coy, 1844

Genus *Cleiothyridina* Buckman, 1906

Cleiothyridina lata Shimer, 1926

Plate 19, figures 1-16; Figure 16

1926 *Cleiothyridina lata* Shimer, p. 71-72, Pl. 4, fig. 1a-c.

1952 *Cleiothyridina lata* Shimer. Brown, p. 104.

1960 *Cleiothyridina lata* Shimer. Brindle, p. 102, Pl. 27, figs. 5-7.

1961 *Cleiothyridina lata* Shimer. Nelson, Pl. 4, figs. 2-4.

1967 *Cleiothyridina lata* Shimer. Macqueen and Bamber, p. 32, Pl. 1, figs. 5, 6.

1970 *Cleiothyridina lata* Shimer. Bamber and Copeland, Pl. 12, fig. 1.

Description. Moderately large for genus, unequally biconvex; outline transversely subovate to subcircular; greatest width attained near mid-length; lateral profile subquadrate to lenticular; anterior commissure strongly uniplicate in large adults; fold and sulcus well developed in anterior half of large shells; lateral margins straight or slightly curved; cardinal extremities well rounded, cardinal margins almost straight between beaks and cardinal extremities; ornament poorly preserved in most specimens, consisting of irregularly spaced lamellae fringed with long, flat spines in well preserved specimens; micro-ornament, if present, not observed; shell substance moderately thin.

Pedicle valve most convex in umbonal region, weakly to moderately inflated, much thinner than brachial valve in large specimens; maximum thickness attained at about mid-length in large shells, posteriorly in smaller shells; umbonal region broad, moderately inflated, projecting little beyond hinge line; lateral slopes flattened, weakly convex to weakly concave near lateral margins; cardinal extremities slightly compressed in some specimens; beak small, short, suberect; foramen rounded, moderately large, not in contact with dorsal umbo; beak ridges weakly produced, rounded, defining small, concave palintropes; delthyrium low, very wide, open but partially occluded by dorsal beak; sulcus originating as shallow depression in anterior portion of umbonal region, becoming moderately deep and dorsally directed at anterior margin, producing moderately sized tongue. Pedicle valve interior, with short, stout, diverging, concave dental plates and broad, blade-like teeth.

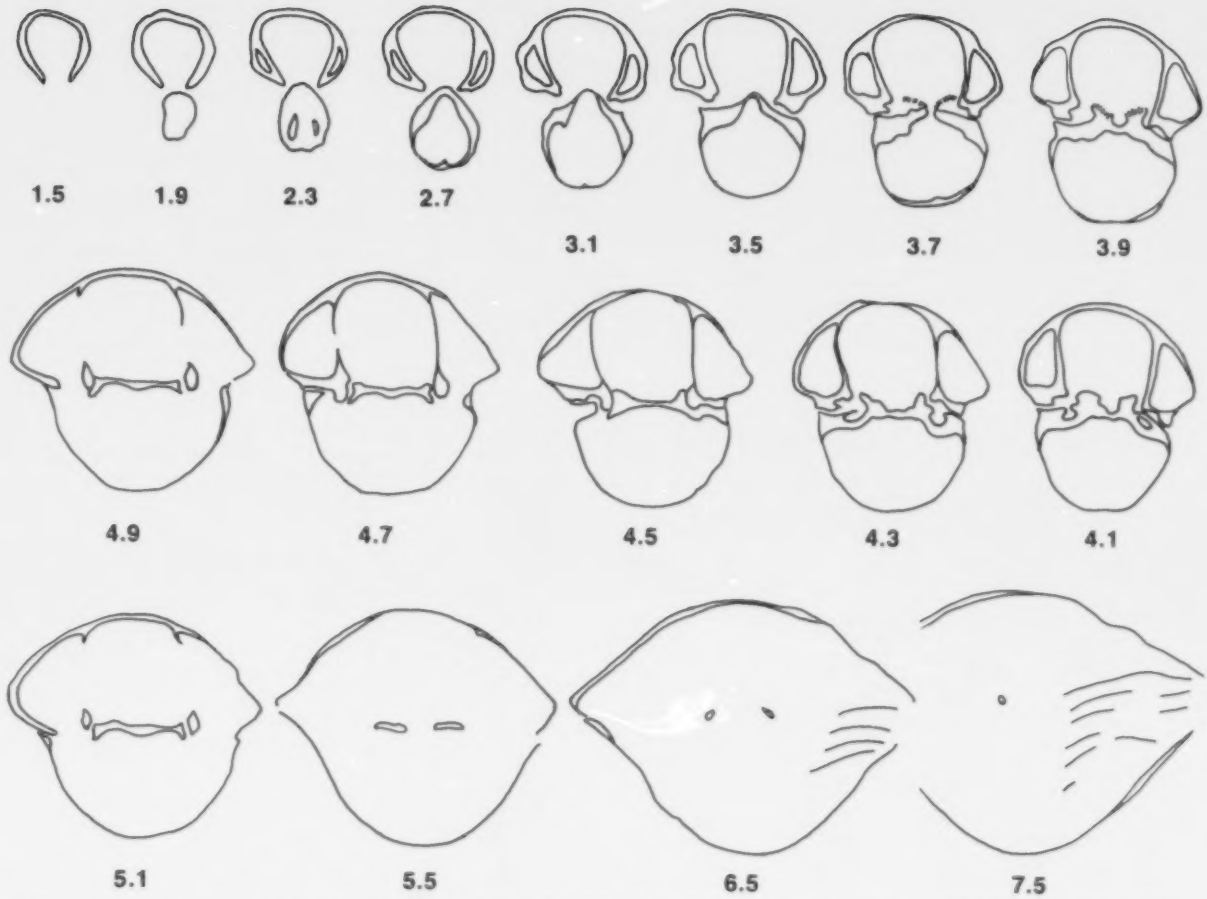

Figure 16. *Transverse serial sections (x2.3) of* ***Cleiothyridina lata*** *Shimer, GSC 63350, from GSC locality 49690. The measurements refer to millimetres from the ventral beak.*

Brachial valve strongly inflated in large adults, much thicker than pedicle valve, with maximum thickness attained anteriorly; dorsum strongly arched for entire length, becoming distinct fold on anterior two thirds of valve; umbonal region moderately sized, laterally defined by slight concave flexures; lateral slopes curving steeply to anterolateral margins, weakly convex; dorsal beak small, projecting into base of delthyrium; fold moderately defined in anterior half of large specimens, poorly defined in small specimens.

Brachial valve interior with large, subquadrate, apically perforate hinge plate, posteriorly grooved or concave and narrow, anteriorly flattened and broad; posteriorly projecting flanges of hinge plate striate; crura broad and flattened, attached to anterolateral edges of hinge plate; brachidial details and muscle impressions not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
4841	24.8	+30.3	15.3
63348	36.8	39.8	25.7
63349	34.3	35.2	24.5
10085a	31.4	34.2	21.9

Type material. GSC 4841, Pl. 19, figs. 13-16, from Bed 2-35 of Shimer's Section 2, Lake Minnewanka, Alberta. Referred specimens GSC 63348, 63349, and 10085a from GSC localities 49723, 49690, and 18790, respectively.

Distinguishing characteristics. This species is characterized by its moderately large size, transversely subovate to sublenticular outline, greatly inflated medially arched brachial valve, and suberect beak, which is not in contact with the dorsal umbo.

Comparisons. Only one other Banff Formation species, *Cleiothyridina harkeri* n. sp., is similar to *C. lata*. It can be differentiated from *C. lata* by its much more transverse outline, much less inflated valves, and weaker fold and sulcus. Shimer (1926, p. 72) compared his new species to *Cleiothyridina incrassata* (Hall) and *C. obmaxima* (McChesney), both from the Burlington Limestone of the midcontinent. *Cleiothyridina incrassata* is similar to *C. lata* in many respects and differs only in the following details: its length and width are subequal, it is never very transverse but is commonly slightly elongate, the ventral umbo is more elongate with a much narrower umbonal angle, and the ventral beak is less incurved, sometimes almost straight or weakly suberect.

Cleiothyridina obmaxima is not very similar to *C. lata*, large adults being much larger and much more transverse, and the brachial valve is proportionately thinner and less inflated.

Distribution. This is one of the most widespread species in the Banff Formation. It is found at many localities in both facies and ranges throughout the lower two brachiopod zones and well into the *Avonia minnewankensis-Marginatia burlingtonensis* Zone in the western facies.

In the *Calvustrigis rutherfordi* Zone, eastern facies, it is recorded at the following GSC localities: 18550, 18553, 18555, 18559, 18788, 18790, 31349, 31350, 36760, 36777, 37131, 40263, 49688, 49690, 49692, 49695, 49704, 49705, 49706, 49707, 49710, 49711, 49723, 49726, 49730, 49740, 49741, 49744, 49753, 49758, 66038, 66102, 66113, 66115, 66326, 68459, 68487, 68518, 68519, 74856, C-4129, C-7382, C-86544 and C-86545. It has been recovered from the western facies of this zone at GSC localities 62088, 62101 and 69554.

Cleiothyridina lata is less common in the "upper" member in the western facies but has been found at the following GSC localities: 18293, 18527, 60997, 69567, 69568, C-57470 and C-57471.

Cleiothyridina tenuilineata (Rowley)

Plate 20, figures 1-12

1900 *Athyris tenuilineata* Rowley, p. 264, Pl. 5, figs. 31-33.

1914 *Cleiothyridina tenuilineata* (Rowley). Weller, p. 478-479, Pl. 80, figs. 1-12.

1967 *Cleiothyridina tenuilineata* (Rowley). Carter, p. 344-347, Pl. 16, figs. 8a-13e; Textfig. 21.

Diagnosis. Small for genus, subcircular to subelliptical in outline, with lenticular profile, nearly equally convex valves, rectimarginate or slightly sinuous anterior commissure, fold and sulcus lacking or with slight, mesial flattening or weak depression in one or both valves, and narrow, occasionally slightly elongate, ventral beak.

Comparisons. This species is not very similar to other cleiothyridinas in the Banff Formation fauna due to its small size and lack of fold and sulcus.

In the midcontinent, *Cleiothyridina glenparkensis* Weller from the Fern Glen Formation is similar in outline and profile but differs in its much larger size and its shorter ventral beak. *Cleiothyridina hirsuta* (Hall) of Meramecian age is similar in size and outline to *C. tenuilineata* and may indeed be related. It can be distinguished by its coarser spines, shorter ventral beak, and slightly larger size, and it commonly has a subpentagonal outline.

Distribution. So far this species has been found only in collections from the *Calvustrigis rutherfordi* Zone of the eastern facies, at these GSC localities: 31347, 36770, 36777, 49688, 49690, 49754, 68459, 68519, C-4130 and C-11787.

Cleiothyridina harkeri n. sp.

Plate 19, figures 24-27

1961 *Cleiothyridina obmaxima* (McChesney)? Nelson, Pl. 4, figs. 5, 6.

Description. Large for genus, subequally biconvex, transversely subelliptical in outline; lateral profile guttate; anterior commissure weakly uniplicate; fold and sulcus weakly developed; cardinal and lateral margins rounded; ornament consisting of overlapping lamellae fringed with moderately narrow, flattened spines; shell substance of moderate thickness.

Pedicle valve moderately inflated, most convex in umbonal region; lateral slopes flattened, weakly convex anteriorly, weakly concave laterally defining moderately compressed cardinal extremities; umbonal region of moderate width, projecting slightly beyond hinge line; beak suberect to erect; foramen and delthyrium not observed; sulcus originating in umbonal region as shallow depression, becoming broader anteriorly but remaining shallow and rounded throughout. Pedicle valve interior with dental plates; other internal details not observed.

Brachial valve moderately inflated, most convex in umbonal region, with greatest thickness in posterior half of valve; umbonal region slightly gibbous, projecting beyond hinge line, defined by concave flexures on each side; beak not observed; lateral slopes moderately and evenly convex; cardinal extremities moderately compressed; fold very low and obscurely defined for most of its length, becoming slightly higher at anterior commissure. Brachial valve interior not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63354	36.3	+53.2	20.1

Type material. Holotype, GSC 63354, Pl. 19, figs. 24-27, from GSC locality 18527.

Distinguishing characteristics. This species can be differentiated by its large size, transversely subelliptical outline, weakly uniplicate anterior commissure and weak fold and sulcus, and relatively small ventral beak that projects very little beyond the hinge line.

Comparisons. Cleiothyridina obmaxima (McChesney) is the only other large, transverse *Cleiothyridina* found in the Lower Mississippian of North America. It differs from *C. harkeri* n. sp. in its larger size and greater thickness (especially the brachial valve), and it has a very well developed fold and sulcus.

Remarks. The description given above is based on a single spalled specimen from GSC locality 18527, Sunwapta Pass, Alberta. Although this specimen is nearly complete, the valves are slightly crushed posteriorly, thus obscuring some morphological details. Nevertheless, the specimen is well enough preserved to suggest that it is quite dissimilar to previously described Lower Mississippian species. Although most of the shell is spalled, the presence of a small portion of the exterior ornament of spine fringed lamellae confirms assignment to the genus *Cleiothyridina*.

Nelson (1961, Pl. 4, figs. 5, 6) illustrated a fine specimen of this species, questionably referring it to *C. obmaxima* (McChesney).

Distribution. Both Nelson's specimen and the one described above are from the western facies. Nelson attributed his specimen to the *Calvustrigis rutherfordi* Zone. The individual described above is associated with species that suggest the *Stegacanthia* cf. *S. bowsheri-Marginatia ferrglenensis* Zone.

Cleiothyridina miettensis n. sp.

Plate 19, figures 17-23

Description. Smaller than average for genus, unequally biconvex; outline transversely subovate or subelliptical; greatest width at about mid-length; anterior commissure uniplicate; fold and sulcus well developed in anterior two thirds of shell; cardinal margins weakly curved, lateral extremities well rounded; ornament consisting of short, overlapping, closely spaced lamellae fringed with very fine, flattened spines; shell substance thin.

Pedicle valve much less inflated than opposite valve, most convex anteriorly in sulcus; umbonal region slightly swollen; lateral slopes flattened or weakly concave; lateral and anterior margins rimmed with thin, distinctive flange approximately at right angles to valve surface; beak short, straight, with relatively large, rounded foramen; beak ridges and palintropes lacking; delthyrium continuous with foramen, open; rounded sulcus originating approximately at mid-length, becoming deep anteriorly and forming dorsally directed tongue. Pedicle valve interior with thin, dental plates.

Brachial valve strongly inflated, medially arched with moderately high, rounded fold that originates in umbonal region, becoming moderately high anterior to mid-length, then becoming truncated and lower at anterior margin; lateral slopes concave near fold then sloping steeply to lateral margins; umbonal region moderately broad, projecting posteriorly beyond hinge line.

Brachial valve interior with subquadrate hinge plate; other cardinalia and brachidium not observed; adductor field narrowly elliptical, moderately impressed.

Dimensions (mm).

GSC no.	Length	Width
63355 (PV)	5.0	6.9
63356 (BV)	6.8	+7.9

PV = pedicle valve; BV = brachial valve.

Type material. The discrete pedicle and brachial valves GSC 63355 and 63356, illustrated in Plate 19, figs. 17-23 are selected as syntypes, from GSC locality C-28282.

Distinguishing characteristics. This species is characterized by its diminutive size, strong fold and sulcus, transverse subelliptical outline, and the rim-like flange that extends around the lateral and anterior margins of the pedicle valve.

Comparisons. Cleiothyridina miettensis n. sp. is not particularly similar to previously described taxa. *Cleiothyridina vestita* Stainbrook, from the Aplington Formation of Iowa (Famennian), is similar in outline, development of the fold and sulcus, and appears to have marginal flanges. However, it differs in being much larger, with convex lateral slopes on the pedicle valve, unlike the concave lateral slopes of *C. miettensis.*

Planalvus gibberosa Carter, from the Gilmore City Limestone of Iowa, is close to *C. miettensis* in size and ornamentation, but it usually has an ovate to elongate outline, the ventral sulcus is more weakly developed, usually lacking, and internally it lacks dental plates.

Remarks. The small size of these specimens suggests that they might be juveniles of some larger species of *Cleiothyridina.* However, two morphological characteristics clearly suggest that these shells are adults, not juveniles. The strongly deflected ventral sulcus, almost at right angles to the lateral margins, and the marginal flange, at right angles to the exterior surface of the pedicle valve, are characters only found in adults of other athyridid taxa.

Distribution. The only collection of this species consists of six disarticulated valves, including types, from GSC locality C-28282, near the Miette Hot Springs, Jasper Park, Alberta.

Genus *Composita* Brown, 1849

Composita athabaskensis Warren, 1932

Plate 21, figures 17-36; Figure 17

1932 *Composita athabaskensis* Warren, p. 248, Pl. 2, figs. 5-11.

1952 *Composita athabaskensis* Warren. Brown, p. 104, Textfig. 15.

1961 *Composita athabaskensis* Warren. Nelson, Pl. 4, figs. 7-11.

Description. Medium size for genus, subequally biconvex, outline subpentagonal to subchordate; greatest width variable; length-width ratio variable but usually longer than wide; lateral profile guttate to subtrigonal; anterior commissure weakly uniplicate; fold usually lacking or very weakly developed at anterior margin; sulcus weakly to strongly developed, flaring anteriorly, producing distinctly emarginate outline in most specimens; cardinal margins straight or weakly convex; anterolateral margins usually moderately rounded; ornament simple, consisting only of irreguarly spaced growth varices; shell substance thin.

Pedicle valve moderately inflated, most convex in umbonal region, attaining maximum thickness well posterior of mid-length; umbonal region broad, usually subtending angle of 90 degrees or more, not elongated, extending little beyond opposite valve; lateral slopes moderately and evenly convex; beak short, slightly incurved; foramen small, rounded to ovate; cardinal margins slightly compressed in some specimens, rounded in others; delthyrium occluded by dorsal umbo; sulcus originating near mid-length in most large specimens, rounded throughout, flaring anteriorly and becoming moderately deep at anterior margin of some specimens.

Pedicle valve interior with slightly diverging short dental plates; teeth elongate, blade-like; muscle field slightly raised and obscurely marked.

Brachial valve also subpentagonal to subchordate in outline, slightly shorter than opposite valve but of about equal thickness and degree of inflation; maximum thickness attained in posterior third of valve; umbonal region moderately inflated, defined by weakly concave lateral flexures, producing slightly compressed cardinal margins; dorsum evenly convex or slightly arched posteriorly, becoming weakly convex to flattened anteriorly; fold not developed except for slight dorsal flexure at anterior margin of some specimens; lateral slopes evenly and moderately convex; beak not observed, hidden within delthyrial chamber of opposite valve.

Brachial valve interior with subquadrate to trapezoidal cardinal plate posterolaterally defined by moderately high, thin flanges forming inner socket ridges; two longitudinal ridges extending entire length of cardinal plate mark position of crural bases; apical perforation moderately large; sockets deep; brachidial details and adductor field not observed.

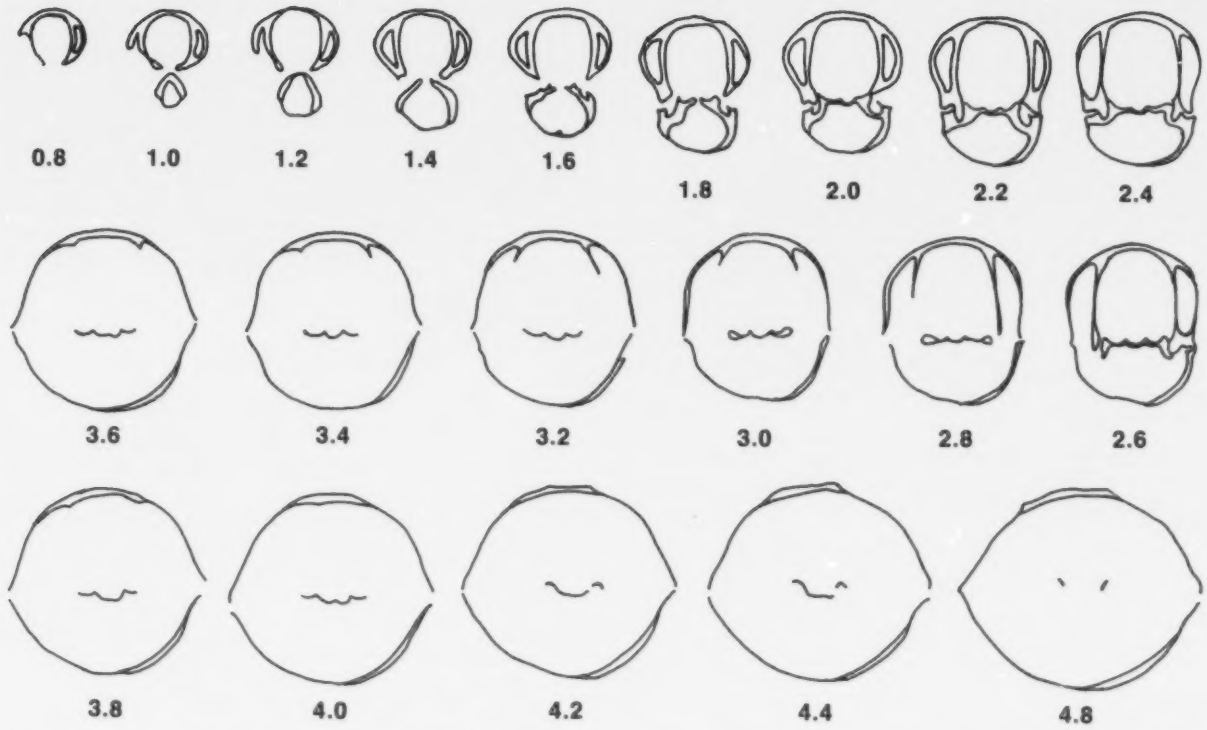

Figure 17. *Transverse serial sections (x3) of* ***Composita athabaskensis*** *Warren, GSC 63358, from GSC locality 49707. The measurements refer to millimetres from the ventral beak.*

Dimensions (mm).

Specimen	Length	Width	Thickness
UA Cb 288	22.8	+22.4	13.6
UA Cb 289	18.0	16.7	11.0
UA Cb 291	22.8	21.0	+10.5
UA Cb 292	19.2	17.6	10.5
UA Cb 293	+16.3	13.8	9.0
UA Cb 294	16.8	14.8	9.5
GSC 63357	26.7	22.7	13.1

Type material. Warren's six syntypes are in the collections of the University of Alberta, numbers Cb 288 (incorrectly printed as Cb 298 on the plate explanation), 289, 291, 292, 293 and 294. The exact locality and horizon at which these specimens were found within the Banff Formation are not known. Presumably all of the syntypes belong to a single collection from the "upper" Banff beds at one of the numerous outcrops northeast of Jasper, Alberta. The four best preserved syntypes are illustrated here (Pl. 21, figs. 21-36).

Distinguishing characteristics. This species can be distinguished by the subpentagonal to subchordate, emarginate outline, guttate lateral profile, the pedicle valve being only slightly longer than the brachial valve with a short, slightly incurved ventral beak, the small foramen, the lack of a fold or one that is very weakly developed only at the anterior margin, and the anteriorly flaring sulcus in the anterior half of the pedicle valve.

Comparisons. Although this well known species is highly variable in its proportions, the emarginate, subpentagonal to subchordate outline, and the absence of a dorsal fold are relatively consistent characteristics that distinguish it from most other Banff representatives of *Composita.*

Warren (in Allan, Warren and Rutherford, 1932, p. 248) compared *Composita athabaskensis* to *Composita madisonensis* (Girty), although, in fact, the two species are not very similar. *Composita madisonensis* has a fairly well defined dorsal fold, a ventral sulcus that originates near the beak, and its pedicle valve is much longer than the brachial valve.

The difference between *Composita athabaskensis* and *Composita immatura* (Girty) are discussed under the latter.

Distribution. Composita athabaskensis is restricted to the *Calvustrigis rutherfordi* Zone of the eastern facies. It is particularly common in the Jasper Park region but occurs throughout the outcrop area of this facies. It has been recovered from the following GSC localities 18553, 18555, 36760, 36777, 37131, 40263, 49688, 49690, 49695, 49698, 49704, 49706, 49707, 49711, 49723, 49727, 49728, 49736, 49740, 49754, 66102, 66113, 66115, 66330, 68457, 68517, 68519, 68521, 68523, C-4129, C-4130, C-7382 and C-86545.

Composita humilis (Girty), 1899

Plate 18, figures 17-40; Figure 18

1899 *Seminula humilis* Girty, p. 565-566, Pl. 71, fig. 6a-c.

1927 *Composita humilis* (Girty). Girty, p. 62, Pl. 22, figs. 38, 39.

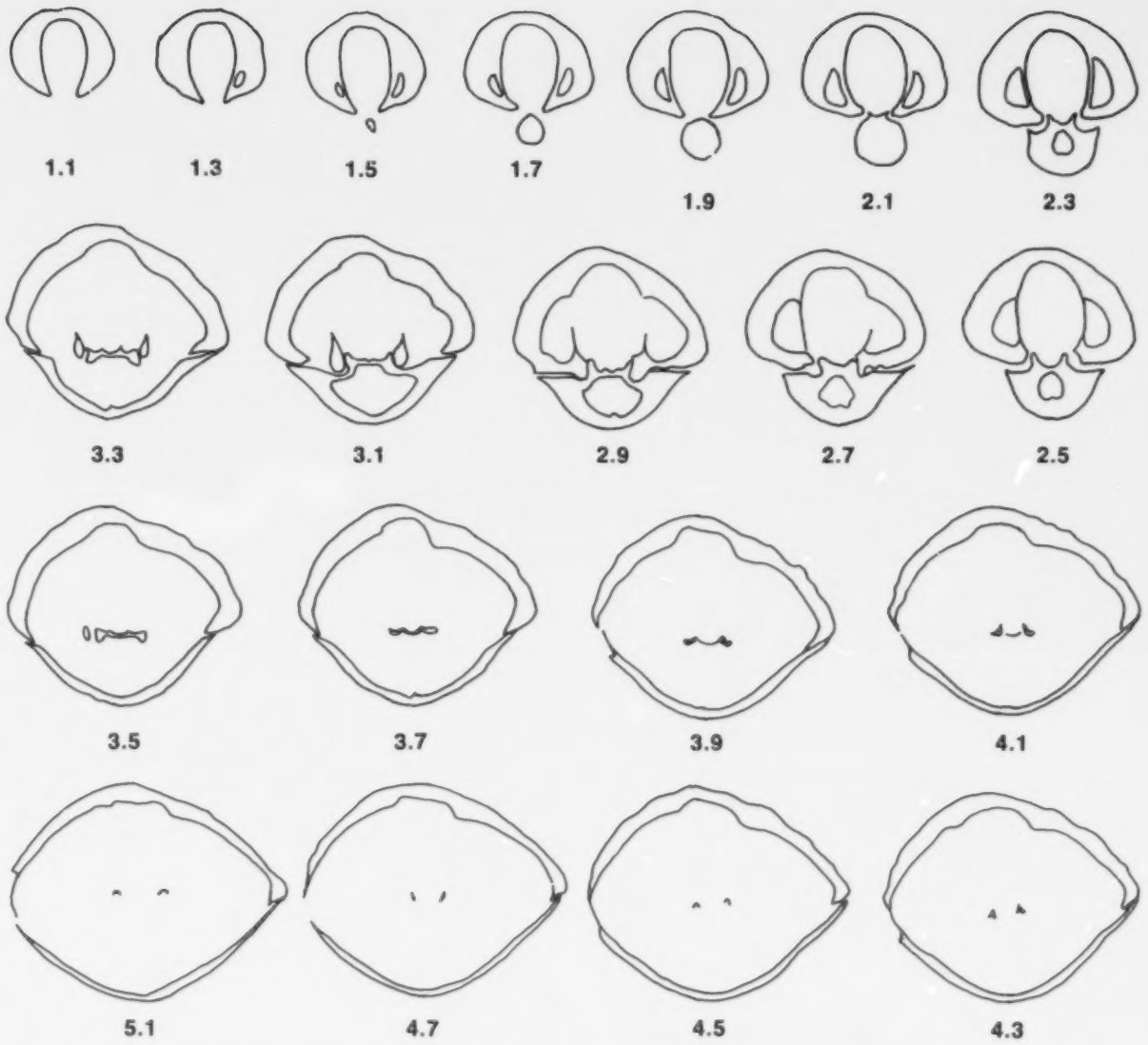

Figure 18. *Transverse serial sections (x3) of* ***Composita humilis*** *(Girty), GSC 63365, from GSC locality 68573. The measurements refer to millimetres from the ventral beak.*

1961 *Composita humilis* (Girty). Nelson, Pl. 4, figs. 14-20.

1972 *Composita humilis*? (Girty). Carter, p. 482-483, Pl. 2, figs. 15-26; Textfig. 2.

Description. Small to medium size for genus, subequally biconvex; outline subcircular or, more rarely, longitudinally subovate; greatest width attained at or posterior to mid-length; lateral profile lenticular; anterior commissure weakly uniplicate to rectimarginate in adults; fold and sulcus weakly developed in adults; ornament lacking except for irregularly spaced growth varices; shell substance moderately thick posteriorly.

Pedicle valve substantially longer than brachial valve, moderately tumid posteriorly; umbonal region broad, gibbous; beak short, incurved, erect; cardinal margins straight or slightly concave in outline, cardinal extremities moderately broad; lateral margins strongly convex in outline, curving abruptly forward from cardinal extremities; delthyrium occluded by dorsal beak; shallow sulcus present in anterior part of some large shells, but commonly lacking; venter may be arched.

Pedicle valve interior with short, slightly diverging medially concave dental plates; teeth broad, large, blade-like; muscle field moderately incised.

Brachial valve subcircular to transversely subovate in outline, moderately inflated, usually thinner than opposite valve; maximum thickness attained near or posterior to mid-length; lateral profile almost evenly convex, slightly more convex in umbonal region; umbonal region moderately inflated, broad, weakly defined by small, anterolaterally

directed flexures; lateral slopes evenly convex, occasionally slightly flattened; dorsum evenly convex or slightly arched; weak, low fold produced in posterior half of some large specimens; dorsal beak small, narrow.

Brachial valve interior with apically perforate subtrapezoidal cardinal plate; thin, high vertical flanges at sides of cardinal plate form inner socket ridges posteriorly; crural bases marked by two longitudinal ribs on ventral surface of cardinal plate; crura triangular near bases, becoming flat and arcuate anteriorly; other brachidial details not observed; short myophragm present posteriorly but adductor field obscure in transverse section.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63359	17.8	17.2	11.9
63360	14.7	13.7	10.0
63361	13.5	12.7	8.5
63362	10.5	9.9	6.5
63363	7.8	7.4	4.3
63364	5.8	5.5	3.2

Type material. Girty's two syntypes from the Madison Limestone of the Yellowstone National Park are in the National Museum of Natural History, Washington, D.C., U.S.A.

Distinguishing characteristics. This species can be differentiated by its moderate size, subcircular to longitudinally subovate outline, absent or weakly developed fold and sulcus, broad, gibbous ventral umbo, incurved, erect ventral beak, broad cardinal extremities, and brachial valve usually noticeably thinner than the pedicle valve, with broad umbonal region weakly defined by lateral flexures.

Comparisons. In the Banff Formation, only *Composita* cf. *C. oblonga* (Tolmachoff) shows much similarity to *C. humilis.* The former differs in having a much more elongate, narrower ventral umbo, a decidedly longitudinally elongate outline with the greatest width more anteriorly located, and the ventral sulcus, even though only a shallow groove, originates in the umbonal region.

Composita esplanadensis Brown, from the Rundle Formation of the Jasper region, is similar in size and general outline to *C. humilis* but differs by its much smaller, narrower ventral umbo, less broad cardinal extremities, and better developed dorsal fold.

Composita pikensis Carter, from the lower Burlington Limestone of Missouri, is a very small species, the adults of which are very similar to juveniles of *C. humilis.* The former, however, have compressed cardinal margins in all growth stages and narrow, short ventral umbones.

Composita obesa Sanders from the Represo Limestone of Sonora is externally very similar to some specimens of *C. humilis* and may be a junior synonym. It differs in being slightly thicker, with a shorter, narrower umbonal region and beak.

Distribution. Five collections of this species are from the *Calvustrigis rutherfordi* Zone of the eastern facies, GSC localities 49690, 49709, 74861, 68455 and 68573. It also occurs at two localities in the western facies, GSC localities 18293 and 73521. The former is from an unzoned horizon in the "upper" member at Mount Rundle, the other from the *Calvustrigis rutherfordi* Zone in the North Cascade section.

Composita immatura (Girty), 1899

Plate 20, figures 29-44; Figure 19

1899 *Seminula immatura* Girty, p. 566, Pl. 71, fig. 5a-d.

1952 *Composita immatura* (Girty). Brown, p. 105, Pl. 5, fig. 4a, b; Textfig. 15.

1961 *Composita immatura* (Girty). Nelson, Pl. 4, figs. 21-23.

Description. Medium size for genus, subequally biconvex, outline longitudinally subovate to guttate; greatest width near or anterior to mid-length; lateral profile guttate, anterior profile subovate, subcircular, or thickly lenticular; anterior commissure weakly uniplicate in large specimens, commonly rectimarginate in juveniles; fold lacking; weak sulcus commonly present in pedicle valve, producing slightly emarginate anterior margin; lateral margins weakly to moderately convex; ornament consisting only of irregularly spaced growth varices; shell substance thin.

Pedicle valve moderately inflated, most convex in umbonal region, evenly convex on middle part of venter, but lateral slopes plunge steeply to lateral margins; maximum thickness attained in posterior half of valve; umbonal region poorly differentiated; beak very short and straight, scarcely projecting posterior to dorsal umbo; foramen rounded; delthyrium occluded by dorsal umbo; sulcus narrow, shallow, originating at about mid-length in large adults.

Pedicle valve interior with short, slightly diverging dental plates; teeth blade-like; muscle field obscurely defined in transverse section.

Brachial valve nearly as long as pedicle valve and very similar in outline, lateral profile, and degree of inflation, with maximum thickness in posterior half; umbonal region most convex, slightly protuberant, narrowly defined by slightly concave flexures; dorsum evenly convex except near anterior margin where it becomes less convex, may be flattened; lateral slopes strongly convex, plunging steeply to lateral margins; beak hidden within delthyrium.

Brachial valve interior with large, trapezoidal nonperforate hinge plate; inner socket ridges formed posteriorly by high, thin flanges; crural bases extending through hinge plate as longitudinal ribs; adductor field obscure in transverse section; brachidial details not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63366	21.5	17.0	12.8
63367	18.2	12.4	11.1
63368	13.8	11.4	8.6
63369	12.7	9.6	8.1

Type material. Girty's two syntypes from the Madison Limestone are in the National Museum of Natural History, Washington, D.C., U.S.A.

Distinguishing characteristics. This species can be differentiated by its elongate, guttate to subovate outline,

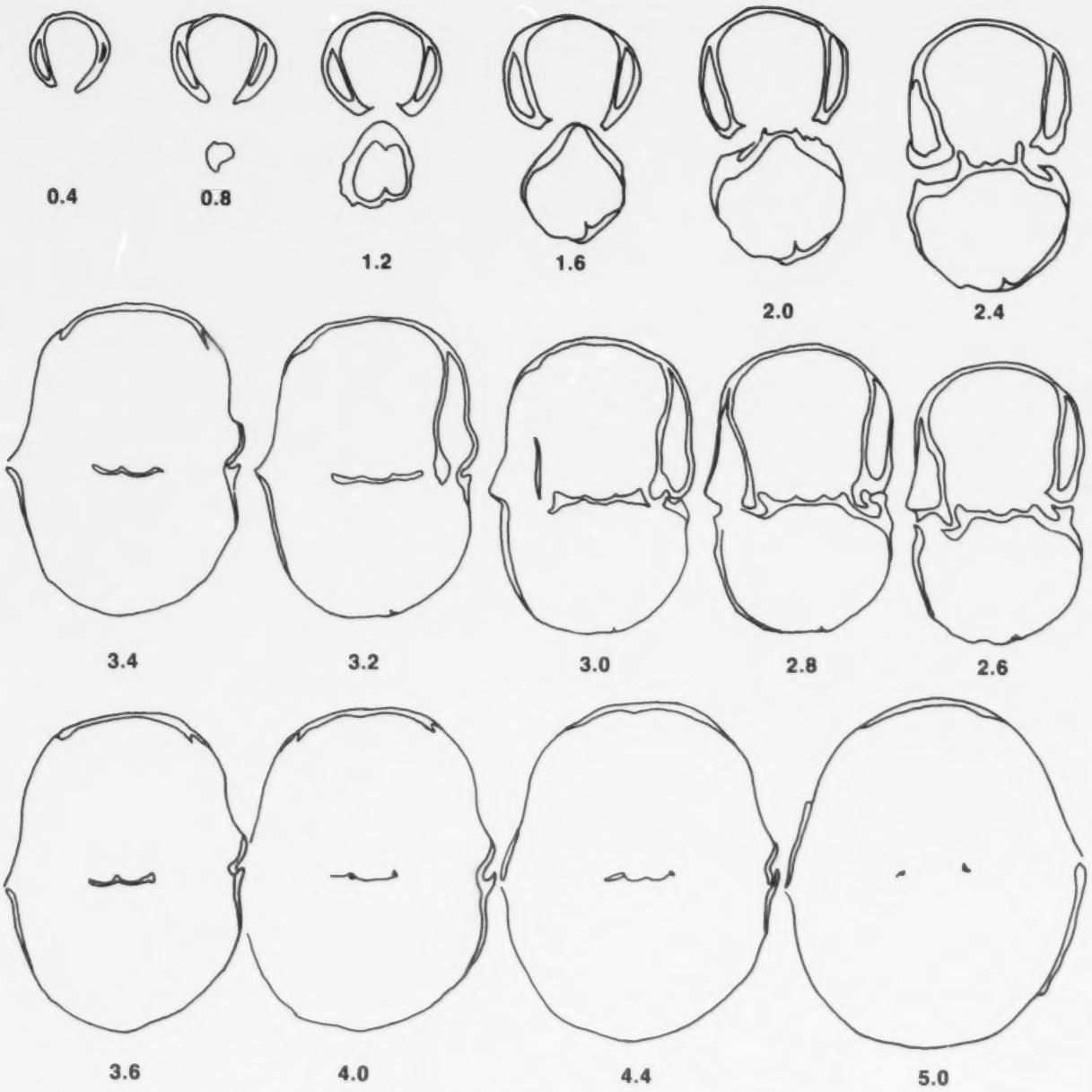

Figure 19. *Transverse serial sections (x4.5) of* ***Composita immatura*** *(Girty), GSC 63370, from GSC locality 19992. The measurements refer to millimetres from the ventral beak.*

guttate lateral profile, subcircular to thickly lenticular anterior profile, valves of nearly equal length and thickness, short straight ventral beak, narrow elongate dorsal umbo, and weak ventral sulcus and anteriorly flattened brachial valve, forming a slightly emarginate outline in most specimens.

Comparisons. Two other Banff representatives of *Composita*, similar to *C. immatura*, are *Composita athabaskensis* Warren and *C. prolixa* n. sp. *Composita athabaskensis* differs from *C. immatura* in having a subpentagonal outline, a thinner, more lenticular lateral profile, a better developed, more angular ventral sulcus, and a longer ventral beak. *Composita prolixa* can be distinguished by its less inflated valves, subovate outline with greatest width near mid-length, broader, less tumid dorsal umbo, and slightly compressed cardinal extremities.

Distribution. This species occurs only in the eastern facies, *Calvustrigis rutherfordi* Zone, at these GSC localities: 18790, 19992, 37131, 49699, 49705 and 66038.

Composita prolixa n. sp.

Plate 20, figures 13-28

1972 *Composita* cf. *C. immatura* (Girty). Carter, p. 483, Pl. 2, figs. 27-30.

Description. Medium size for genus, subequally biconvex, outline subovate; greatest width attained near mid-length; lateral profile lenticular to slightly guttate; anterior profile lenticular; anterior commissure rectimarginate to slightly uniplicate; fold lacking; sulcus lacking to weakly developed; lateral and cardinal margins rounded, usually moderately compressed; ornament consisting only of irregularly spaced growth varices; shell substance thin.

Pedicle valve moderately inflated, most convex near beak; venter evenly convex, except for weak, narrow sulcus in anterior third of some specimens; lateral slopes weakly to moderately convex, curving evenly to lateral margins; umbonal region moderately broad, defined laterally by slightly concave flexures in most specimens; cardinal extremities slightly compressed in most specimens; beak short, suberect, extending posteriorly slightly beyond opposite valve; delthyrium occluded by dorsal umbo. Pedicle valve interior with short, slightly diverging dental plates; other details not observed.

Brachial valve nearly as thick and long as pedicle valve, moderately inflated, subovate in outline; maximum thickness attained slightly posterior to mid-length; dorsum evenly convex, fold lacking; lateral slopes slightly less convex than dorsum, curving evenly to lateral margins; umbonal region moderately broad, defined laterally by weakly concave flexures; cardinal extremities invariably moderately compressed; beak incurved, obscured by pedicle valve. Brachial valve interior not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63371	24.5	20.8	14.6
63372	19.7	16.4	+10.8
63373	15.9	12.9	8.0
63374	12.9	11.3	7.0

Type material. Holotype GSC 63371, from GSC locality 49705, Jasper Park, Alberta, Pl. 20, figs. 13-16. Paratypes GSC 63372-63374, from GSC locality 49705, Jasper Park, Alberta, Pl. 20, figs. 17-28.

Distinguishing characteristics. This species is characterized by the longitudinally subovate outline of both valves, which are nearly equally long and equally inflated, compressed lateral extremities, especially noticeable in the brachial valve, no fold, and a very weak, narrow sulcus in the anterior third of the pedicle valve, or none at all.

Comparisons. In the Banff Formation, only *Composita immatura* (Girty) and *C. athabaskensis* Warren might be confused with *C. prolixa* n. sp. *Composita immatura* differs by having more inflated valves, its outline is guttate, not ovate, the umbonal regions of both valves are narrower and more elongate, and the ventral sulcus is more defined. *Composita athabaskensis* is less likely to be confused with *C. prolixa* due to its subpentagonal outline, better developed ventral sulcus, and emarginate anterior margin.

Athyris claytoni Hall and Whitfield from the Madison Group of Utah is similar to *C. prolixa* in size and outline but differs in having a pedicle valve that is much longer than the brachial valve, the ventral beak is much more tumid, incurved and erect, and the brachial valve is almost circular in outline. *Seminula madisonensis* var. *pusilla* Girty differs from *C. prolixa* in a similar manner, and may be a junior synonym of *C. claytoni.*

Distribution. This rare species occurs at only three localities in the eastern facies, *Calvustrigis rutherfordi* Zone, GSC localities 49699, 49705 and 66330.

Composita cf. *C. oblonga* (Tolmachoff), 1924

Plate 21, figures 1-16

1924 *Seminula oblonga* Tolmachoff, p. 140.

1931 *Seminula oblonga* Tolmachoff, p. 551, Pl. 6, figs. 33-36.

Description. Medium size for genus, subequally biconvex, outline longitudinally subpentagonal to subovate; greatest width attained near or anterior to mid-length; lateral profile thinly lenticular; anterior commissure weakly uniplicate; fold and sulcus weakly developed; ornament simple, consisting of irregularly spaced growth varices.

Pedicle valve moderately to strongly convex, thicker and more inflated than opposite valve; umbonal region moderately tumid, elongate, projecting posteriorly well beyond brachial umbo, usually subtending umbonal angle of less than 90 degrees; lateral slopes strongly convex, curving abruptly to lateral margins; cardinal extremities well rounded, slightly compressed in smaller specimens, margins convex in larger specimens; maximum thickness attained in posterior half of valve; beak of moderate breadth, incurved, erect; delthyrium occluded by dorsal umbo; sulcus very weakly developed, commonly only a shallow depression on venter, originating in umbonal region; dental plates short.

Brachial valve less inflated than pedicle valve, most convex in umbonal region; outline subcircular; maximum thickness attained in posterior third of valve; dorsum slightly arched posteriorly, lateral slopes moderately convex posteriorly, becoming flattened or very weakly concave anteriorly; umbonal region of moderate breadth, slightly inflated, defined by concave posterolateral flexures; beak not observed; fold very weakly developed, originating in anterior half of large shells, defined only by weakly flattened areas of lateral slopes or slight elevation near anterior margin; interior details not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63375	21.4	±18.0	13.3
63376	20.3	18.4	13.6
63377	16.4	±15.3	9.7
63378	13.4	12.3	8.4

Distinguishing characteristics. This species is characterized by its longitudinally subpentagonal to subovate outline, thickly lenticular profile, elongate, moderately narrow ventral umbo with incurved, erect beak, strongly convex pedicle valve, and weakly developed fold and sulcus.

Comparisons. The elongate umbo, strongly convex pedicle valve, and very weakly developed fold and sulcus distinguish this species from most specimens of *Composita* from the Banff Formation, such as *Composita athabaskensis* and *C. immatura.*

Composita prolixa n. sp. is the Banff species most similar to *C.* cf. *C. oblonga*, also having an elongate ventral umbo, thick, lenticular profile, and weakly developed fold and sulcus. It is readily distinguished by its longitudinally ovate brachial valve, straighter ventral beak, and lack of a dorsal fold.

Composita oblonga (Tolmachoff) was described from the Kuznets Basin of Siberia. The type specimen is of late Tournaisian age, but Beznosova (1963, p. 325) has identified this species in Viséan beds of the Kuznets Basin as well. Few specimens of this Soviet species have been illustrated. These Canadian specimens are few in number and not very well preserved, precluding a positive identification.

Distribution. Composita cf. *C. oblonga* is a rare species in the Banff Formation. It occurs at only three localities, all from the *Calvustrigis rutherfordi* Zone. The collections from GSC localities 31347 and 31349 are from the Miette Hot Springs area, eastern facies, and a small collection of three specimens from Mount Rundle, GSC locality 69550, appears to belong here.

Genus *Pseudopentagonia* Beznosova, 1963

Pseudopentagonia cf. *P. injensis*
Beznosova, 1963

Plate 19, figures 28-31

1963 *Pseudopentagonia injensis* Beznosova, p. 316-317, Pl. 60, fig. 4; Textfig. 140.

Discussion. This unique specimen, from GSC locality 49746, is externally similar to a species from the Tournaisian of the Kuznets Basin, as described by Beznosova (1963, p. 316). Externally, it differs in being smaller with more concave lateral slopes on both valves and distinctly compressed cardinal margins. Also, Beznosova described the genus *Pseudopentagonia* as having a smooth surface, whereas this Banff species, although spalled, has the weak radial ribs characteristic of spalled *Cleiothyridina*, and a bit of lamellose shell is preserved at the anterior margins. Although Beznosova diagnosed her genus as being smooth (1963, p. 315), she stated that some specimens may have weak radial striae on inner surfaces in her description of the type species. Because loss of the spine fringed lamellae of cleiothyridinas is very common it seems possible that *Pseudopentagonia* may, in fact, not have an entirely smooth external surface, and I feel justified in comparing this Canadian species to the Soviet one from the Kuzbas.

Cleiothyridina prouti (Swallow) from the Fern Glen Formation of Missouri and the Lake Valley Formation of New Mexico, is similar to these Soviet and Canadian species in outline and general aspect but differs in having strongly convex lateral slopes and a very clearly costellate radial ornament in well preserved shells.

Athyridid gen. et sp. indet.

Plate 15, figures 49-52

Description. Medium size for family, subequally biconvex, outline subpentagonal, length and width about equal; greatest width near or anterior to mid-length; lateral profile thickly lenticular to crudely subquadrate; anterior commissure strongly uniplicate; fold and sulcus well developed anteriorly; ornament consisting of irregularly spaced growth varices and faint costellae on outer subsurface shell layers; outermost shell surface not preserved; shell substance impunctate and probably of moderate thickness.

Pedicle valve strongly inflated, gibbous; umbonal region moderately elongate, subtending umbonal angle of less than 90 degrees; beak narrow, incurved, suberect; lateral slopes strongly convex, sloping steeply to cardinal margins, less steeply to anterolateral margins; sulcus shallow, flat bottomed to gently rounded, originating in anterior half of largest specimens; cardinal margins not compressed; delthyrium occluded by dorsal umbo; dental plates moderately long, diverging slightly.

Brachial valve subtrigonal to subpentagonal in outline, of about same thickness as opposite valve; position of maximum thickness variable, dependent on height of fold; umbonal region moderately narrow, elongate, moderately to strongly tumid; lateral slopes strongly convex, sloping steeply to cardinal margins and anterolateral margins; dorsum arched posteriorly, rising anteriorly to become well defined fold in anterior half or more of valve; dorsal beak not observed; internal details not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
10087a	23.5	22.0	18.2
10087b	22.7	22.6	+15.5
10087c	+17.7	19.1	12.8

Remarks. The preceeding description is based on three spalled, but otherwise nearly complete, enigmatic shells from GSC locality 18788, Jasper Park, Alberta. One specimen is crushed and in another the ventral beak is missing. The most complete and best preserved specimen is illustrated in Plate 15.

These specimens have the general shape and proportions that one normally associates with the genus *Composita*. However, two of the specimens clearly have a weakly costellate ornament preserved in the shell layers near the surface of both valves. Because the original external ornament may not be preserved on any of these specimens one hesitates to draw definitive conclusions from this weakly impressed ornamentation. The weakly costellate ornament is certainly suggestive of the genus *Cleiothyridina*, but no other North American Lower Mississippian species of that genus with the size, shape and proportions of the above specimens are known to the author.

Order SPIRIFERIDA Waagen, 1883

Suborder SPIRIFERIDINA Waagen, 1883

Superfamily CYRTIACEA Frederiks, 1924

Family AMBOCOELIIDAE George, 1931

Genus *Ambocoelia* Hall, 1860

Ambocoelia magna Shimer, 1926

Plate 2, figures 27, 28

1926 *Ambocoelia magna* Shimer, p. 66, Pl. 3, figs. 3a-4b.

Discussion. Shimer apparently based this species on two pedicle valves, a holotype and one paratype. Both specimens are incomplete, with anterior portions of the valves missing, and are altogether rather poorly preserved. The paratype, GSC 4817a, illustrated here (Pl. 2, fig. 28) has a broken beak, revealing dental plates, and is obviously not an ambocoeliid at all. The holotype, GSC 4817, gives no indication of internal structures, but is very similar externally to the paratype and is probably the same species. If the holotype possesses dental plates, *Ambocoelia magna* is probably a junior synonym of *Eomartiniopsis rostrata* (Girty), a fairly common Banff brachiopod. With the lack of certain knowledge about the internal morphology of the holotype, and with the absence of additional specimens, it is perhaps most prudent to regard this species as a *nomen dubium.*

Distribution. According to Shimer (1926, p. 66) these specimens were recovered from his Bed 2-35 at Lake Minnewanka. This bed occurs within the *Calvustrigis rutherfordi* Zone. Shimer did not record the presence of this species at his other measured sections, nor have subsequent authors reported it elsewhere in Alberta.

Genus *Crurithyris* George, 1931

Crurithyris cf. *C. laevicula* (Rowley), 1900

Plate 2, figures 25, 26

1900 *Ambocoelia laevicula* Rowley, p. 262-263, Pl. 5, figs. 12-14.

Discussion. The various collections upon which this identification is based contain a number of specimens of undoubted ambocoeliid affinities. Before Shimer's types were examined it was tentatively assumed that these specimens were representatives of *Ambocoelia magna* Shimer. As pointed out above, Shimer's species is at best a *nomen dubium* and possibly a synonym of *Eomartiniopsis rostrata* (Girty). Although these Banff ambocoeliids are somewhat larger than usual for North American Lower Mississippian species, they appear to be similar in most respects to *Crurithyris laevicula* (Rowley), originally described from the lower Burlington Limestone of Missouri. As well as the discrepancy in size, the Banff specimens have a slightly stronger dorsal sulcus than is usual in topotypic specimens of *C. laevicula.*

Distribution. This species occurs at six localities in the *Calvustrigis rutherfordi* Zone of the eastern facies, GSC localities 31367, 36782, 49692, 49752, 68459 and 68522.

Superfamily SPIRIFERACEA King, 1846

Family LICHAREWIIDAE Slusareva, 1958

Genus *Calvustrigis* n. gen.

Type species. Spirifer rutherfordi Warren, 1932, from the Banff Formation of Alberta.

Diagnosis. Medium size, impunctate, transverse spiriferaceans with low, simple, strap-like costae and narrow intercostal furrows on the flanks; bald, moderately well developed fold and sulcus, strongly denticulate apsacline to orthocline, weakly concave ventral interarea, small ventral beak, and strongly capillate micro-ornament. Internally, the posterior parts of both valves are greatly thickened with secondary prismatic shell material, the dental adminicula are strong and slightly divergent, a short subdelthyrial plate is present, and the cardinal process is supported by a thick callus.

Comparisons. Calvustrigis n. gen. is not very similar to other Mississippian or Lower Carboniferous genera. *Acuminothyris* Roberts, from the Tournaisian of New South Wales, Australia, is similar in having a transverse outline and a smooth fold and sulcus, but differs in having alate, angular, not mucronate, lateral extremities, disproportionately large sulcus-bounding costae, deep fold-bounding furrows, and an imbricate, weakly capillate ornament. Carter (1974, p. 677) previously assigned *Acuminothyris* to the subfamily Strophopleurinae.

Alispirifer Campbell, from the Upper Carboniferous of eastern Australia, is similar to *Calvustrigis* in several respects, having a transverse outline, mucronate cardinal extremities in adults, and a bald fold and sulcus. It differs in having strong, rounded costae with deep, rounded, intercostal furrows, the costae may occasionally bifurcate, and some species have a median costa in the sulcus.

Species assigned. Lower Carboniferous, transverse, impunctate spiriferaceans with a noncostate fold and sulcus are rare. No other previously described species can be assigned to this new genus with confidence. It may ultimately be proved that *Delthyris mesastrialis* Hall, from the Chemung Group (Frasnian) of New York, and *Spirifer winchelli* Herrick, from the Waverly Group of Ohio, belong here. Denticulation of the ventral interarea and capillate micro-orament, diagnostic characters of most true spiriferaceans, have not yet been established for these species.

Remarks. Familial assignment for this new genus is difficult. In many respects *Calvustrigis* n. gen. is similar to members of both the Spinocyrtiidae and Licharewiidae, which have the smooth fold and sulcus, simple costae, thickened posterior internal structures, and capillate or modified capillate micro-ornament of *Calvustrigis.* As Pitrat (1965, p. H692) pointed out, these two groups are very similar in almost every internal and external respect and are differentiated mainly because of the long hiatus separating their stratigraphic occurrences. *Calvustrigis* n. gen. is assigned to the Licharewiidae mainly because the name has priority over Spinocyrtiidae.

Derivation of name. Latin, *calvus,* smooth; Latin, *strigis* furrow or groove, referring to the non-costate sulcus.

Calvustrigis rutherfordi (Warren), 1932

Plate 2, figure 31; Plate 22, figures 1-8; Figure 20

1932 *Spirifer rutherfordi* Warren, in Allan, Warren and Rutherford, p. 247-248, Pl. 2, figs. 1-4.

1952 *Platyrachella rutherfordi* (Warren). Brown, p. 64, p. 94-95, Pl. 5, fig. 6a-e; Textfig. 14.

Description. Average size for family, moderately biconvex, much wider than long in all observable growth stages; outline transversely subelliptical to subquadrate; lateral extremities subangular and usually slightly mucronate in all observable growth stages; greatest width attained at hinge line in all but earliest growth stages; smooth, rounded fold and sulcus moderately well developed and of moderate width, originating at beaks of both valves; anterior commissure weakly to moderately uniplicate; ornament consisting of

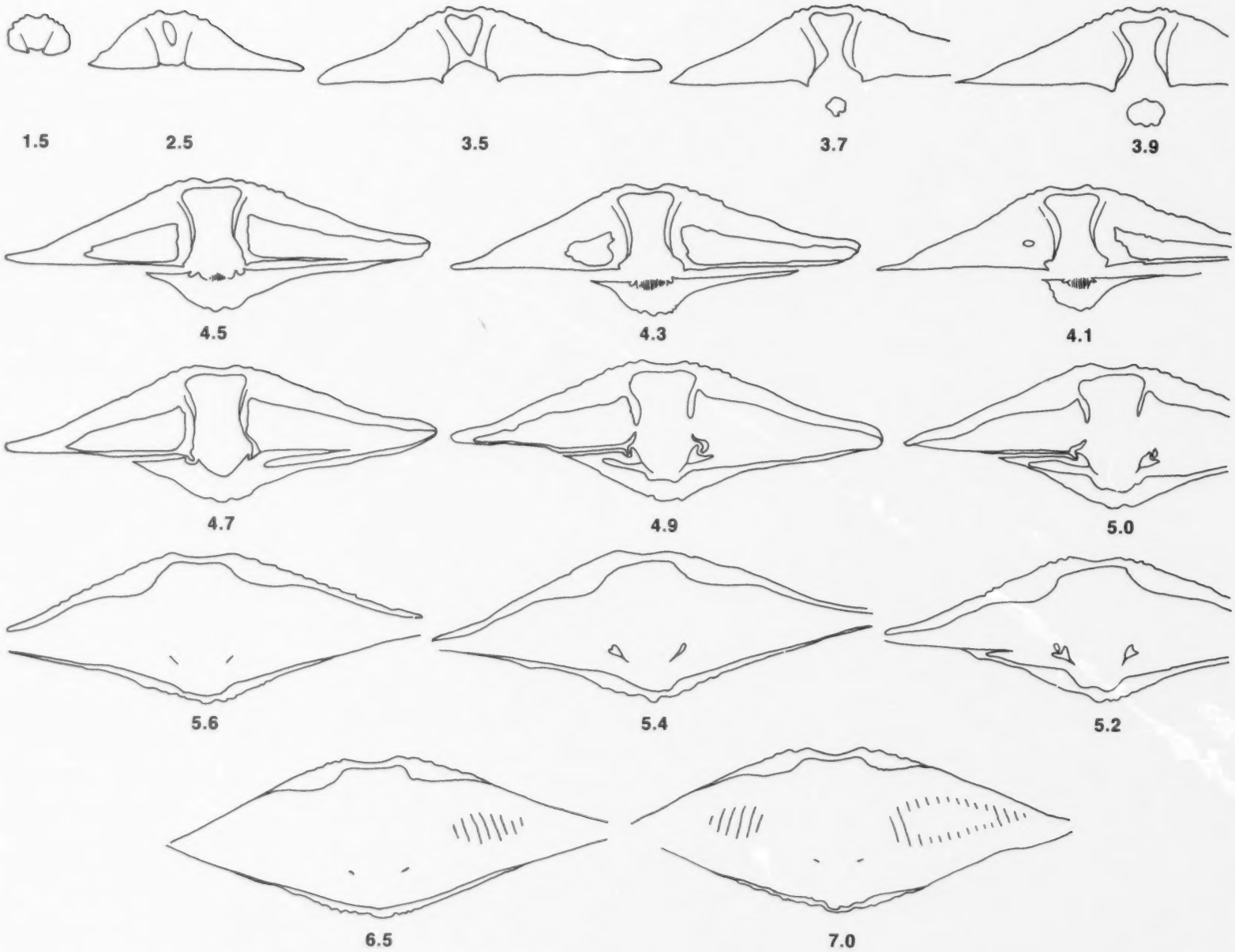

Figure 20. *Transverse serial sections (x3) of* ***Calvustrigis rutherfordi*** *(Warren), GSC 63385, from GSC locality 49707. The measurements refer to millimetres from the ventral beak.*

about sixteen to twenty-five, usually about twenty, low, rounded, strap-like, simple costae with narrow intercostal furrows on the flanks, irregularly spaced growth varices, strong capillae on whole surface, about 6 to 8 per mm, and very fine, fairly regularly spaced growth lines forming cancellate pattern, occasionally with tiny nodes at poin*s of intersection with capillae; shell substance impunctate; both valves much thickened posteriorly with secondary columnar shell matter.

Pedicle valve moderately and evenly convex in lateral profile, with small, slightly incurved beak; flanks weakly convex, becoming flattened laterally, with slightly concave flexures near lateral extremities; interarea of moderate height, weakly concave or flattened laterally, acutely triangular, with numerous coarse denticle grooves, apsacline to almost orthocline; hinge line denticulate; delthyrium apparently open, of variable width, but not wider than high; sulcus shallow throughout length, usually evenly rounded in well preserved specimens; sulcus-bounding costae slightly broader and higher than those of flanks; costae near lateral extremities often very faint and difficult to distinguish; dental adminicula well developed, thick, diverging slightly; teeth small; apical callosity of moderate thickness; subdelthyrial plate well developed.

Brachial valve about as thick as pedicle valve, most convex in umbonal region, moderately convex on flanks with weakly concave flexures near lateral extremities; fold of moderate height throughout its length, rounded or may be slightly flattened anteriorly (both syntypes illustrated in Plate 22 have distorted folds), delimited by broader and slightly deeper fold-bounding furrows than those of flanks; dorsal interarea low, orthocline; cardinal process striated, broad, supported by mass of callus; sockets small; crural bases directed dorsomedially, attached to medial surface of socket ridges; no tabellae present; spiralia composed of numerous whorls.

Dimensions (mm).

Specimen	Length	Width	Thickness	Number of costae/flank
UA Cb 295	21.8	35.5	-	16
UA Cb 296	+25.3	+36.2	14.8	+15
UA Cb 297	±28.0	+40.8	+15.4	17
GSC 63383	26.2	62.6 (0.5x2)	-	+18
GSC 63384	22.4	50.1	-	22

Type material. Warren's three syntypes, University of Alberta Cb 295, 296 and 297, two of which are illustrated here (Pl. 22, figs. 2-8), are in the collections of the University of Alberta.

Distinguishing characteristics. This species is characterized by its transverse semielliptical to subquadrate outline, very small ventral beak, orthocline to apsacline, flattened to weakly concave ventral interarea, smooth fold and sulcus, about twenty simple strap-like costae per flank, and strongly capillate micro-ornament.

Comparisons. Calvustrigis rutherfordi (Warren) is not very similar to other Lower Mississippian spiriferaceans in Alberta.

There are two enigmatic spiriferacean species from New York and Ohio that are at least superficially similar to *Calvustrigis rutherfordi.* These are *Spirifer mesacostalis* Hall, from the Chemung Group (Frasnian) of New York, and *Spirifer winchelli* Herrick, from the Waverly Group of Ohio. Both of these species have a strongly transverse outline, mucronate lateral extremities, simple lateral costae, and a smooth sulcus. Unfortunately, both species are known only from moulds and casts, and they lack evidence of either denticulation of the hinge or a capillate micro-ornament. They are also smaller than *C. rutherfordi,* have fewer lateral ribs and possess a medial groove on the dorsal fold.

Distribution. The very large brachiopod faunal assemblage that characterizes the "middle" member of the Banff Formation in the western facies and the upper beds of the formation in the eastern facies takes its name from this distinctive, common species. Unfortunately, it has not been positively identified in the western facies and may be restricted to the eastern facies. It occurs at the following GSC localities in the eastern facies: 31347, 31349, 31350, 36760, 36777, 37131, 40263, 49690, 49692, 49695, 49704, 49705, 49706, 49707, 49709, 49711, 49719, 49723, 49726, 49730, 49738, 49740, 49750, 49751, 49753, 49756, 49757, 66038, 66102, 66113, 66115, 66330, 68455, 68457, 68487, 68516, 68517, 68522, 74859, C-4129, C-4130, C-7382, C-7383 and C-86545.

Family SPIRIFERIDAE King, 1846

Subfamily STROPHOPLEURINAE Carter, 1974

Genus *Voiseyella* Roberts, 1964

Voiseyella texana (Carter), 1967

Plate 23, figures 14-19

1961 *Spiriferella* sp.? Nelson, Pl. 7, figs. 10-12.

1967 *Amesopleura texana* Carter, p. 371-374, Pl. 15, fig. 20; Pl. 27, figs. 12a-26; Textfig. 30.

Remarks. This species is extremely rare in the Banff Formation. Nelson (1961) illustrated a nearly complete specimen from the Sawback Creek area, Alberta, and there are two specimens in the GSC collections, both from an unzoned collection from the "upper" member, GSC locality 73526. The best of the last two, a nearly complete shell, is illustrated here. All of these specimens have nine or ten simple lateral costae and the moderately inflated profile characteristic of *Voiseyella texana* (Carter), which was originally described from the Chappel Limestone of central Texas. The specimen illustrated here differs slightly from the Chappel Limestone specimens externally in possessing an obscure median costa in the sulcus. The other specimen from GSC locality 73526, and Nelson's specimen, lack this median costa. Internally, a sectioned specimen lacks an elongated mass of callus supporting the cardinal process, and apparently lacks the thickened ridges that internally reflect the fold-bounding grooves.

It is possible that the callus deposits described by Carter (1967, p. 364) in *Voiseyella novamexicana* (Miller) and *V. texana* (1967, p. 368, 372), and taken to be of generic significance, are actually environmentally induced. However, all specimens of the genus *Voiseyella* from New Mexico, Texas, and Missouri that have been sectioned by the author do possess these callus deposits. The single Banff Formation specimen available for sectioning may be unique or uncharacteristic.

Subfamily PROSPIRINAE Carter, 1974

Genus *Prospira* Maxwell, 1954

Prospira cf. *P. albapinensis*
(Hall and Whitfield), 1877

Plate 23, figures 20, 21, 26-33

1877 *Spirifera albapinensis* Hall and Whitfield, p. 255, Pl. 4, figs. 7, 8.

Description. Medium size for genus, subequally biconvex, pedicle valve more inflated than brachial valve; outline transversely subsemicircular; greatest width at hinge line; lateral extremities subangular, slightly to moderately mucronate in most specimens; fold and sulcus moderately developed, narrow, well defined by disproportionately large, sulcus-bounding costae and deep, fold-bounding grooves in most specimens; anterior commissure uniplicate; macro-ornament consisting of numerous, high, rounded, simple costae, and irregularly spaced growth varices; sulcus with one to five, usually three, costae; flanks with about fifteen or sixteen costae; micro-ornament consisting of fine, strong regularly spaced growth lines; capillae not observed; umbonal regions of both valves considerably thickened with callus.

Pedicle valve moderately inflated, most convex in umbonal region; maximum thickness attained approximately at right angles to hinge line; flanks weakly convex, sloping evenly to anterolateral margins; lateral extremities slightly compressed, delineated by weakly concave flexures; beak small, narrow, slightly incurved; beak ridges subangular, well defined; interarea acutely triangular, weakly to moderately concave, of moderate height, apsacline, vertically grooved in some specimens; hinge line denticulate; delthyrium almost as high as wide, apparently open; sulcus originating at beak as narrow groove, forming sulcal angle of approximately fifteen to twenty degrees, shallow, rounded; median sulcal costa invariably simple, originating in umbonal region, usually well defined; lateral sulcal costae originate by splitting from sulcus-bounding costae and remain simple for entire length.

Pedicle valve interior with stout, thick, dental adminicula; ventral muscle field deeply impressed in large specimens; teeth small.

Brachial valve less inflated than pedicle valve; umbonal region only slightly more convex than lateral slopes; lateral slopes curving evenly to anterolateral margins; lateral extremities slightly compressed as in opposite valve, delimited by weakly concave flexures; beak inconspicuous; dorsal interarea very low, acutely triangular, slightly concave, anacline; fold originating at beak as low median rib sharply delimited by deep bounding grooves, becoming wider and higher anteriorly but attaining only moderate height; fold with distinct median groove that first appears in umbonal region, other fold costae complementary to those of opposite valve; first two costae on either side of fold formed by bifurcation, other lateral costae simple.

Brachial valve interior with striate cardinal process supported posterodorsally by callus; inner socket ridges low and narrow; crura attached to dorsomedial surfaces of inner socket ridges; broad myophragm or median ridge separating moderately impressed adductor scars; spiralia composed of only six or seven whorls in sectioned specimen.

Distinguishing characteristics. This species is characterized by its moderate size, mucronate lateral extremities, narrow fold and sulcus, which is sharply delimited by disproportionately large, sulcus-bounding costae and deep, fold-bounding grooves, a few sulcal costae with invariably simple median costa, and fifteen or sixteen strong, high, simple, rounded lateral costae on each flank.

Comparisons. This species is not easily confused with most of the Banff Formation spiriferids because of its smaller size, narrow, well defined fold and sulcus, and distinctive ornamentation. Smaller specimens of *Unispirifer minnewankensis* (Shimer) might be confused with *Prospira* cf. *P. albapinensis*, but can be distinguished by their lower costae, some of which may bifurcate; the fold and sulcus are wider, and, ordinarily, there are more numerous lateral costae.

Prospira cf. *P. albapinensis* is most similar to *Spirifer biplicoides* Weller, from the Prospect Hill Sandstone of Iowa. The latter is smaller, with slightly fewer costae. The costae of *S. biplicoides* appear to be lower and flatter than those of the Banff species but the sandstone impressions of the Iowa species are not well enough preserved for one to be sure of this characteristic. The lateral extremities are more consistently mucronate and usually more extended than those of the Banff species.

Remarks. Hall and Whitfield's types and other topotypic specimens of *Spirifer albapinensis* must be restudied and redescribed before it is possible for one to make a positive identification of this species. Girty (1899, p. 548) believed *S. albapinensis* to be a junior subjective synonym of *Spirifer centronatus* Winchell. Armstrong (1958) has shown *Spirifer centronatus* s.s. to be a much larger, more robust form with a more rounded anterolateral outline. It lacks the disproportionately large sulcus-bounding costae of *S. albapinensis*. The two forms do not appear to be conspecific.

Distribution. These small spiriferids appear to range throughout the fossiliferous parts of the Banff Formation in both facies, although the species never occurs in large numbers at any single locality. It is recorded from the following GSC localities: 49704, 49692, 60995, 60997, 62087, 62089, 66038, 66112, 66119, 66332, 68519, 68523, 69548, 69550, 69554, 69555, C-57469, C-86543 and C-86544.

Prospira fessaulacis n. sp.

Plate 26, figures 15-26

Description. Medium size for genus, unequally biconvex, pedicle valve more inflated than brachial valve; outline transversely subelliptical to subovate in adults; greatest width attained at or slightly anterior to hinge line; lateral extremities truncated, subangular; fold and sulcus weakly to moderately developed; anterior commissure uniplicate; ornament consisting of low, simple, rounded costae separated by moderately broad, rounded, intercostal furrows, irregularly spaced growth varices, fine capillae, and irregularly spaced growth lines; sulcus with one or three costae; median sulcal costa weakly defined in some specimens; lateral sulcal costae usually weaker and more poorly defined than median costa, bifurcating, when present, from sulcus-bounding costae; each lateral slope with twelve to fifteen costae, becoming fine and obscure near cardinal extremities; shell substance greatly thickened with callus.

Pedicle valve moderately inflated, most convex in umbonal region, maximum thickness attained posterior, or nearly at right angles, to hinge line; umbonal region broad, only moderately protruding beyond hinge line; lateral slopes less convex, sloping evenly to anterolateral margins; cardinal

extremities moderately compressed, defined by moderately concave flexures, subangular to weakly mucronate in early growth stages; beak small, narrow, incurved over apex of delthyrium; beak ridges angular, sharply defined; interarea moderately high, acutely triangular, flattened or weakly concave, strongly apsacline to orthocline, vertically grooved in weathered specimens; hinge line denticulate; delthyrium usually higher than wide, partially to almost completely occluded by overlapping deltidial plates; sulcus originating at beak as narrow groove, becoming moderately wider anteriorly but remaining shallow throughout and poorly to moderately defined; sulcus-bounding costae commonly poorly differentiated from sulcus anteriorly, may be incorporated into sulcus.

Pedicle valve interior much thickened with callus; dental adminicula buried in callus posteriorly, moderately long, subparallel or moderately divergent; thick, subdelthyrial callus usually formed posteriorly between adminicula, filling posterior portion of delthyrial cavity; muscle field deeply impressed, chordate; teeth small, blade-like.

Brachial valve moderately inflated, most convex in umbonal region; lateral slopes weakly convex, sloping gently to anterolateral margins; cardinal extremities moderately compressed, delimited by weakly concave flexures; beak inconspicuous; dorsal interarea very low, acutely triangular, anacline; fold originating in beak region as low, narrow, median rib, defined by bounding furrows slightly deeper than other intercostal furrows; fold remaining low and of moderate breadth throughout its length, occasionally rising slightly above lateral slopes, defined essentially by fold-bounding grooves; costae on fold very weak, commonly obscurely developed, although medial groove usually present.

Brachial valve interior with thickened umbonal region; striate cardinal process supported by thick callus posteriorly; inner socket ridges low, rounded; crural bases attached to dorsomedial edges of inner socket ridges; weak median ridge present in adductor field; spiralia composed of approximately eleven or twelve whorls; adductor field moderately impressed.

Dimensions (mm).

GSC no.	Length	Width	Thickness	Lateral costae
63390	17.6	32.0	12.2	13
63391	-	27.0	12.4	12
63392	17.2	±22.2	12.4	12
63393	15.2	18.4	10.7	10

Type material. Holotype, GSC 63390, from GSC locality 68448, Pl. 26, figs. 15-18. Paratypes, GSC 63391, from GSC locality 68448, Pl. 26, fig. 19; GSC 63392, from GSC locality 68567, Pl. 26, figs. 20-22; GSC 63393, from GSC locality 49688, Pl. 26, figs. 23-26.

Distinguishing characteristics. This species can be recognized by its transversely subelliptical outline, truncated cardinal extremities, broad ventral umbonal region, weakly developed and poorly defined sulcus in most specimens, one or three weak to moderately defined sulcal costae, and twelve to fifteen simple, low, rounded lateral costae, separated by moderately broad, rounded, intercostal furrows.

Comparisons. Prospira fessaulacis n. sp. is not very similar to other Banff spiriferids and can be readily distinguished from most species by its ornamentation alone.

Spirifer vantuyli Moore, from the Chouteau Limestone of Missouri, is a small, coarsely ribbed species with subelliptical outline. It differs from *P. fessaulacis* in having fewer costae with more narrow intercostal furrows, and has a truncated ventral interarea with beak ridges that are almost parallel to the hinge line.

Distribution. Prospira fessaulacis n. sp. occurs only in the *Calvustrigis rutherfordi* Zone, and is common only at the Fagan Lake section, GSC localities 68447, 68448, 68449, 68451 and 68452. A few specimens have also been found at the following GSC localities of the eastern facies: 49688, 68522, 68567, 74866 and C-86544. In the western facies, it has been identified only at GSC locality 73521.

Genus *Unispirifer* Campbell, 1957

Unispirifer greenockensis (Brown), 1952

Plate 25, figures 24-38; Figure 21

1952 *Spirifer greenockensis* Brown, p. 64, 98-99, Pl. 4, fig. 5a-c; Textfig. 14.

1960 *Spirifer* cf. *greenockensis* Brown. Brindle, p. 96, Pl. 24, fig. 9.

1961 *Spirifer greenockensis* Brown. Nelson, Pl. 5, figs. 11-13; not Pl. 7, figs. 8, 9.

1967 *Spirifer* cf. *S. greenockensis* Brown. Rodriguez and Gutschick, p. 377-378, Pl. 43, figs. 9, 10, 17-21; Textfig. 6A.

Description. Medium size for genus, unequally biconvex with pedicle valve thickest; outline transversely semiovate in medium sized shells, becoming elongate in largest adults, with some large shells nasute at anteromedial margin; greatest width usually attained at hinge line; lateral extremities subangular; fold and sulcus weakly to moderately developed and commonly poorly defined; anterior commissure weakly uniplicate; ornament consisting of numerous, low, rounded costae with narrow interspaces, irregularly spaced growth varices, fine, regularly spaced growth lines and fine capillae; lateral costae becoming progressively finer and more obscure near cardinal extremities, usually simple, occasionally with one, or very rarely with two, bifurcating costae, usually not near sulcus; number of lateral costae varies from about seventeen to twenty-six per flank, usually approximately twenty to twenty-two in medium sized specimens and about twenty-four to twenty-six in largest shells; holotype with about twenty-one simple costae on each flank; sulcus usually with about eight costae, consisting of five primary costae, any or all of which may split once; median pair may split once more for maximum of twelve costae in sulcus of exceptional specimens; shell substance moderately thick in umbonal region.

Pedicle valve most convex in umbonal region, moderately inflated; maximum thickness attained at right angles to hinge line; umbonal regional broad, moderately produced; flanks weakly convex, sloping evenly to lateral margins of broad specimens or sloping steeply to lateral commissure of more elongate valves; lateral extremities moderately compressed, defined by concave flexures, mucronate in early growth stages, becoming subangular in large adults; beak small, incurved; beak ridges well defined, subangular to sharply angular; interarea of moderate height, concave, acutely triangular in immature specimens, abruptly truncated in large adults, apsacline, usually vertically

grooved; hinge line denticulate; delthyrium usually somewhat higher than wide in adults, partially occluded by several overlapping thin deltidial plates; sulcus very shallow, poorly defined, of moderate width, originating at beak as groove, not achieving much depth even at anterior margin of most specimens; sulcus-bounding costae of normal proportions, giving rise to first two pairs of lateral sulcal costae; median sulcal costa of greater width than lateral sulcal costae, usually delimited by deeper intercostal furrows, occasionally raised on low ridge or plication (see Pl. 25, figs. 25, 38).

Pedicle valve interior with short, stout, moderately diverging dental adminicula; teeth small; muscle field impressed in large specimens; umbonal region substantially thickened with secondary shell tissue but subdelthyrial plate not produced.

Brachial valve less inflated than pedicle valve, most convex in umbonal region; flanks weakly convex, with weakly concave flexures defining slightly compressed lateral extremities; dorsal beak inconspicuous; dorsal interarea very low, acutely triangular, anacline or nearly orthocline; fold originating at dorsal beak, rounded, of moderate width, remaining low throughout but delimited by distinct fold-bounding grooves.

Brachial valve interior with striate cardinal process, posteriorly supported by short, low, callus deposit; sockets small; socket ridges thin, low; crural bases nearly vertical, attached to dorsomedial surfaces of inner socket ridges; spiralia composed of numerous whorls; adductor field weakly impressed.

Dimensions (mm).

Type no.	Length	Width	Thickness	Number of sulcal costae	Number of lateral costae
GSC 9204	30.7	35.7	±11.5	8	21
GSC 63394	+33.0	40.4	12.6	9	24
GSC 63395	21.2	25.3	8.6	5	23
GSC 63396	20.8	30.5	10.1	5	21
GSC 63397	32.7	±27.8	12.0	12	+16
GSC 63398	24.0	30.0	+14.2	5	+18
GSC 63399	17.4	±22.8	11.0	8	18
GSC 63400	24.4	±37.5	15.0	7	+20

Type material. Holotype GSC 9204, a pedicle valve, Pl. 25, fig. 24. Paratypes GSC 9206-9207, pedicle valves.

Distinguishing characteristics. This species is characterized by its mucronate transverse outline in juveniles, which becomes elongate, even nasute, with subangular or truncated cardinal extremities in adults; the low, rounded, lateral costae are usually simple, numbering about twenty to twenty-six in adults; the sulcus is shallow and inconspicuous, but the low, rounded fold is well delimited by distinct fold-bounding grooves; the sulcal costae number five to twelve, usually about eight, and the median costa almost always bifurcates in large adults and is commonly raised on a low plication.

Comparisons. Other spiriferids in the Banff Formation that might be confused with *Unispirifer greenockensis* include *Unispirifer minnewankensis* (Shimer), *Prospira albapinensis* (Hall and Whitfield), and *Prospira fessaulacis* n. sp.

Unispirifer minnewankensis, which usually occurs in slightly younger beds, is distinguished by its more transverse outline in all growth stages, well defined sulcus, less numerous and better defined lateral costae, fewer sulcal costae (usually only five or six), and the median sulcal costa is not as broad, raised, or defined by deeper intercostal grooves. Early growth stages of the two species are virtually impossible to differentiate.

Prospira albapinensis, which was originally described from the Madison Group, is a poorly known spiriferid that may generally resemble immature specimens of *U. greenockensis*. Adult specimens of these two species, however, are readily distinguished by their different outlines, ornamentation, and development of fold and sulcus.

Some specimens of *Prospira fessaulacis* n. sp. have truncated lateral extremities, a moderately elongate outline, simple costae on the flanks, and a weakly developed sulcus. Although this species has a similar stratigraphic range, it is easily distinguished from *U. greenockensis* by its fewer coarser costae on both flanks and fold and sulcus. Mature specimens of *P. fessaulacis* have only one or three sulcal costae, in sharp contrast to *U. greenockensis*, which has five to twelve sulcal costae in mature shells.

Other North American species that bear a reasonably close resemblance to *U. greenockensis* are *Spirifer centronatus invalidistriatus* Hyde, from the Waverly Group of Ohio; *Prospira corpulenta* (Carter), from the lower Burlington Limestone of Missouri; *Prospira* aff. *P. greenockensis* (Brown) of Carter (1972, p. 486, 487), from the Gilmore City Limestone of Iowa; and *Mirifusella fortunata* Carter, from the Hampton Formation of Iowa.

Spirifer centronatus invalidistriatus is commonly elongate but differs from *U. greenockensis* in having fewer ribs on both the flanks and fold and sulcus, the median sulcal costa is simple, and the outline is not nasute even in the largest shells as it is in *U. greenockensis*.

Prospira corpulenta is usually similar in outline to *U. greenockensis*, commonly becoming elongate in large specimens. It differs in having fewer lateral ribs, only about sixteen to nineteen, the median sulcal costa is simple, the sulcus is better defined, and the lateral profile is much more inflated.

Prospira aff. *P. greenockensis* (Brown) of Carter (1972) probably represents an undescribed new species. It can be distinguished from *U. greenockensis* by its smaller number of lateral costae (about sixteen to twenty in the largest specimens), better defined sulcus, fewer sulcal costae with only the median costa splitting, more robust profile, and generally more transverse outline.

Mirifusella fortunata is similar to *U. greenockensis* in having a bifurcating median sulcal costa, weakly defined sulcus, and elongate outline in large adult specimens. It is readily distinguished by its excessively elongated umbonal region, far fewer costae, and the fact that the maximum width is usually attained anterior to the hinge line in adult specimens.

Distribution. Unispirifer greenockensis is restricted to the *Calvustrigis rutherfordi* Zone. It is fairly common in the eastern facies, occurring at the following GSC localities: 36755, 36760, 36777, 40263, 49692, 49695, 49698, 49699, 49705, 49706, 49707, 49711, 49719, 49722, 49726, 49733, 49741, 49753, 49757, 49758, 49759, 66329, 66330, 68487, 68519, 74866, C-4129, C-11787 and C-86542. In the western facies, it occurs at only three GSC localities: 62089, 62101 and 69548.

A very closely related subspecies commonly occurs in the uppermost Pekisko and lowermost Shunda formations in the Cadomin, Alberta, area.

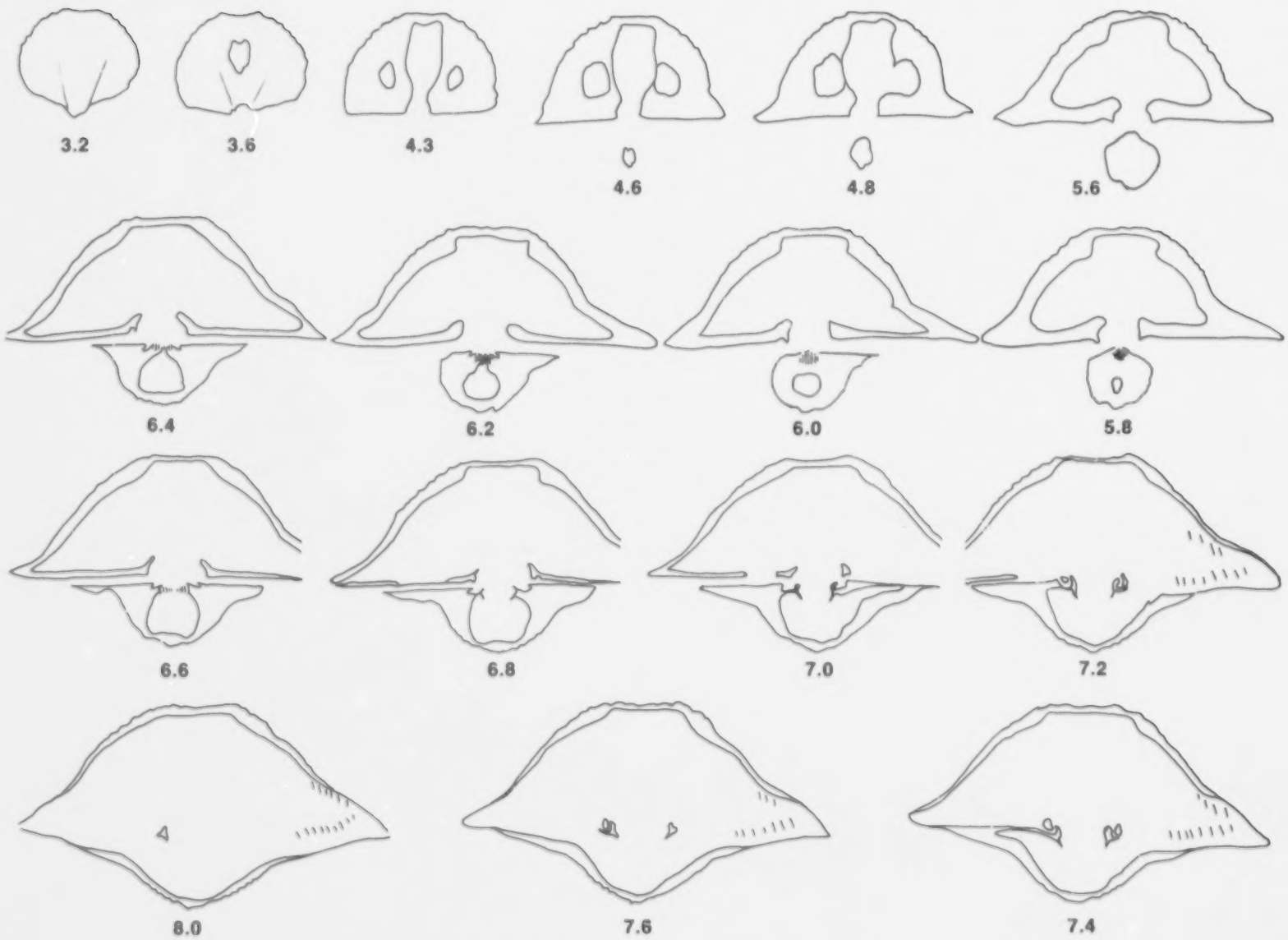

Figure 21. *Transverse serial sections (x2.3) of* ***Unispirifer greenockensis*** *(Brown), GSC 63401, from GSC locality 49692. The measurements refer to millimetres from the ventral beak.*

Unispirifer minnewankensis (Shimer), 1926

Plate 23, figures 1-13, 22-25

1926 *Spirifer centronatus* var. *minnewankensis* Shimer, p. 52-53, Pl. 1, fig. 8a-b.

1952 *Spirifer minnewankensis* Shimer. Brown, p. 64, 100-101, Pl. 4, fig. 6a-d; Textfig. 14.

1958 *Spirifer centronatus* var. *minnewankensis* Shimer. Patton, Pl. 1, figs. 7, 8.

1960 *Spirifer minnewankensis* Shimer. Brindle, p. 98, Pl. 25, fig. 3.

1961 *Spirifer minnewankensis* Shimer. Nelson, Pl. 7, figs. 5, 6.

1961 *Spirifer forbesi* Norwood and Pratten. Nelson, Pl. 7, figs. 1-4.

1970 *Spirifer minnewankensis* Shimer. Bamber and Copeland, Pl. 12, fig. 9.

Description. Medium size for genus, subequally biconvex, pedicle valve more inflated than brachial valve; outline transversely subsemicircular; greatest width normally attained at hinge line; lateral extremities subangular, occasionally slightly alate in well preserved specimens; fold and sulcus moderately developed, narrow, well defined; anterior commissure uniplicate; ornament consisting of numerous simple costae, irregularly spaced growth varices, fine capillae, and fine, regularly spaced growth lines; sulcus with median costa, which originates near beak and may bifurcate once near mid-length; lateral sulcal costae bifurcating from sulcus-bounding costae, two on each side of sulcus, occasionally bifurcating once again; costae on flanks usually simple, rounded, well defined by narrow intercostal furrows, numbering approximately eighteen to twenty-four in adult specimens; bifurcation of lateral costae, if present, limited to one or two per flank on pedicle valve; costae nearest fold-bounding grooves almost invariably bifurcate once near dorsal umbo; shell substance of moderate thickness.

Pedicle valve most convex in umbonal region, maximum thickness attained posterior to mid-length; umbonal region of moderate breadth, projecting moderately posterior to hinge line; flanks gently convex, sloping evenly to anterolateral margins; lateral extremities subangular, commonly alate, rarely weakly mucronate, moderately compressed, delimited by weak, concave flexures; beak small, slightly incurved; beak ridges angular to subangular, sharply defining interarea; interarea weakly to moderately concave, of moderate height, acutely triangular, may be truncated at lateral extremities, apsacline; hingeline denticulate; width of delthyrium approximately same as height, partially occluded by deltidial plates at apex; sulcus originating at beak as groove, becoming rounded anteriorly, remaining moderately shallow for entire length, forming sulcal angle of about sixteen to nineteen degrees; sulcus-bounding costae usually of normal size, or more rarely, slightly enlarged.

Pedicle valve interior with short, stout, slightly diverging dental adminicula that enclose posterior portion of muscle field; subdelthyrial callus or plate commonly present; median ridge produced in some specimens; muscle field moderately impressed; teeth small; ovarian pits observed in some specimens.

Brachial valve less inflated than pedicle valve, most convex in slightly swollen umbonal region; flanks gently convex, sloping evenly to anterolateral margins; lateral extremities moderately compressed, delimited by weakly concave flexures; dorsal beak very small, inconspicuous; dorsal interarea acutely triangular, very low, concave, anacline; fold originating at beak as inconspicuous, rounded medial plication defined by deep, fold-bounding grooves, becoming broader and higher anteriorly but never rising much above lateral slopes, clearly delineated throughout by disproportionately deep fold-bounding grooves.

Brachial valve interior with striate cardinal process composed of numerous plates, supported dorsally by moderate callus; inner socket ridges narrow, moderately high, rising above plane of commissure; sockets narrow, becoming wider anterolaterally; brachidial structures not observed; posterior adductor field ovate, small, impressed near cardinalia; median ridge arising anterior to posterior adductors and extending forward to about two thirds of valve length; numerous ovarian pits on posterolateral half or more of valve; inner edge of interarea with numerous tiny sockets corresponding to denticles of opposite valve.

Dimensions (mm).

Type no.	Length	Width	Thickness	Number of sulcal ribs	Number of lateral ribs
GSC 4630	14.4	±39.6	-	6	21
GSC 63404	28.2	43.1	-	5	19
GSC 63405	23.7	±39.0	16.0	5	19
GSC 63406	19.8	+39.3	12.8	6	22

Type material. Holotype, GSC 4630, an immature pedicle valve, Pl. 23, fig. 1. Shimer (1926, p. 18) attributed the type locality (his Bed 2-25) to the lower Rundle Limestone. Examination of Shimer's Section 2 at Lake Minnewanka has failed to produce even fragments of *U. minnewankensis* in the Livingstone Formation, whereas it is fairly common in the "upper" member of the Banff Formation, as used by Warren (1927) and Macqueen and Bamber (1968). Shimer measured and collected this portion of his Section 2 near the shoreline. Because the water level is now much higher than it was in Shimer's day, it is not possible to be certain of his formational boundaries. It seems reasonable to assume that Shimer's holotype came from the upper Banff Formation, probably 200 feet (61 m) or more below the base of the Livingstone as presently defined.

Distinguishing characteristics. This species is characterized by its transversely subsemicircular outline with alate cardinal extremities, shallow, rounded, well defined sulcus with five to eight sulcal costae, a median sulcal costa that may bifurcate once, eighteen to twenty-four lateral costae that rarely bifurcate, and a low, rounded fold that is clearly delimited by deep fold-bounding grooves.

Comparisons. The differences between this species and *Unispirifer greenockensis* are discussed above.

Unispirifer minnewankensis was originally identified as a variety of *Spirifer centronatus* Winchell, a poorly known species described from the Cuyahoga Formation of Ohio. Although Winchell gave a scanty description of his species and did not illustrate the holotype, this species has been widely identified in the Cordilleran Region. As Hyde (1953, p. 259) pointed out, *S. centronatus* may be a junior synonym of *Spirifer osagensis* Swallow, which was described from the Hannibal Shale of Missouri. Armstrong (1958, p. 21) noted that *S. centronatus* is rare at its type locality and accurate characterization of the species is therefore difficult.

Armstrong illustrated Winchell's holotype for the first time (1958, Pl. 1, fig. 1) plus another topotype specimen. From his description and illustrations, it is apparent that *Unispirifer minnewankensis* is not closely related to *S. centronatus*. The latter seemingly has mucronate, not alate, lateral extremities in all growth stages, an invariably simple median costa in the sulcus, and fewer simple lateral costae in most specimens.

Hall and Whitfield (1877, p. 255) described a similar species, *Spirifer albapinensis*, from Lower Mississippian strata of Utah and Nevada. This species may be synonymous with some of the Cordilleran forms described as *Spirifer centronatus*, and can be distinguished in a similar manner.

Unispirifer minnewankensis is most similar to the following North American species: *Spirifer platynotus* Weller, from the Starr's Cave Oolite and Prospect Hill Sandstone of Iowa; *Spirifer forbesi* Norwood and Pratten, from the Burlington Limestone of the midcontinent and New Mexico; *Unispirifer balki* Armstrong, from the Keating and Lake Valley formations of New Mexico; and *Prospira* aff. *P. greenockensis* (Brown) of Carter (1972, p. 486) from the Gilmore City Limestone of Iowa.

Unispirifer platynotus (Weller) is very similar to small or immature specimens of *U. minnewankensis* but differs in the following details: there are slightly fewer ribs on the flanks, only about sixteen to twenty in most specimens; the outline is more consistently alate, with straighter anterolateral margins than is usual for *U. minnewankensis*; and the fold of *U. platynotus* is very low, scarcely rising above the flanks.

Unispirifer forbesi is more readily distinguished. It is more transverse and has more numerous, invariably simple lateral costae, the median sulcal costa does not bifurcate, the anterolateral margins are straight, forming uniformly angular alate lateral extremities, and the fold is flattened.

Unispirifer balki is a small species with mucronate lateral extremities and a more transverse outline than fully mature specimens of *U. minnewankensis*. It also has a simple median costa in the sulcus and a more inflated umbonal region.

Some individuals of *Prospira* aff. *P. greenockensis* (Brown) of Carter (1972) are similar to *U. minnewankensis* in outline and alate lateral extremities. However, this species has fewer lateral costae, and the sulcus-bounding costae tend to be disproportionately larger than the other adjacent costae. This Gilmore City Limestone species is highly variable in outline and most specimens have a substantially different outline from that of typical *U. minnewankensis* specimens.

Distribution. *Unispirifer minnewankensis* (Shimer) is probably the most common Banff brachiopod in the western facies. It ranges throughout all three zones well into the basal Livingstone Formation, although it is very rare in the lowest zone, the *Calvustrigis rutherfordi* Zone. It occurs sparingly in the *Calvustrigis rutherfordi* Zone in the eastern facies, but is common in the lower Rundle Group in this area. In the western facies it has been found at these GSC localities: 18527, 57859, 60995, 62038, 62040, 62107, 66347, 68593, 69547, 69555, 69557, 69558, 69559, 69560, 69565, 69567, 69569, 69570, 69571, 69572, 73526, 73527, 73528, 74893, C-57468, C-57470 and C-57471. In the eastern facies it occurs at the following GSC localities: 49707, 66331 and 68522.

Unispirifer rundlensis (Warren), 1927

Plate 24, figures 11-15

1927 *Spirifer rundlensis* Warren, p. 59, Pl. 7, figs. 9, 10.

1961 *Spirifer rundlensis* Warren. Nelson, p. 10, figs. 2, 3.

1970 (?) *Spirifer rundlensis* Warren. Bamber and Copeland, Pl. 12, fig. 12.

Remarks. In the collections of the Geological Survey of Canada there are three specimens of this easily recognized species that are thought to be from the Banff Formation. These specimens were collected by P. Harker in 1949 at Mount Rundle, GSC locality 18293.

Warren's type suite of six syntypes were also collected at Mount Rundle, but from the lower Livingstone Formation, not the Banff.

Nelson's specimens of this species seem to be authentic and were also attributed to the lower Livingstone Formation at Tunnel Mountain and Canmore, both near Mount Rundle.

This species is characterized by its very transverse outline with alate cardinal extremities, very small, short, ventral beak, weakly developed fold and sulcus, and numerous fine, well rounded, simple costae separated by narrow, subangular intercostal furrows. It appears to be very rare in the Livingstone Formation, and, because its stratigraphic range has not been adequately delimited it seems appropriate to illustrate the reasonably well preserved specimens from the Banff Formation, as well as the better syntypes.

Subfamily SPIRIFERINAE King, 1846

Genus *Spirifer* Sowerby, 1816

Spirifer mountraensis n. sp.

Plate 2, figure 29; Plate 24, figures 1-6

1958 *Spirifer* cf. *rowleyi* Weller. Harker and Raasch, Pl. 1, fig. 10.

1967 *Spirifer* cf. *rowleyi* Weller. Macqueen and Bamber, Pl. 1, fig. 7.

1970 *Spirifer* cf. *rowleyi* Weller. Bamber and Copeland, Pl. 12, fig. 10.

Description. Average size for genus, subequally biconvex; strongly transverse with alate or submucronate cardinal extremities and subsemicircular outline in early growth stages, becoming elongate, with truncated subangular to subrounded cardinal extremities and transversely subquadrate to subsemielliptical outline in large adults; sulcus weakly to moderately developed, rounded, not sharply defined; fold moderately well developed anteriorly, rounded; anterior commissure uniplicate; macro-ornament consisting of numerous, low, rounded, simple or bifurcating costae separated by narrow intercostal furrows on entire shell, except for interareas, and strong, irregularly spaced, growth varices; micro-ornament consisting of fine capillae, growth lines not observed; shell substance of moderate thickness for genus.

Pedicle valve moderately to strongly inflated, almost evenly convex in both lateral and posterior views, except for more convex umbonal region; lateral slopes more weakly convex, sloping evenly to anterolateral margins; cardinal extremities slightly to moderately compressed, delimited by weakly concave flexures; cardinal extremities in early growth stages usually slightly mucronate, more rarely angular, becoming truncated to rounded in large adults; beak small, broad, short, incurved; beak ridges angular, well defined, extending laterally almost parallel to hinge line in some specimens; ventral interarea of moderate height, apsacline, strongly concave, forming low, broad, trapezoid or low, wide pentagon, vertically grooved; hinge line denticulate; delthyrium approximately as wide as high, apparently open; sulcus weakly to moderately developed, usually poorly delineated, originating in umbonal region as slightly concave flexure or shallow groove, becoming broad but remaining shallow and poorly defined anteriorly; median sulcal costa originating in beak region between sulcus-bounding costae, latter giving rise to numerous pairs of sulcal costae, each of which, as well as median costa, may in turn bifurcate one or more times; sulcus-bounding costae indistinguishable from those of lateral slopes anteriorly and boundary between lateral slopes and sulcal walls not readily differentiated; about seventy or more costae present on entire surface of valve.

Pedicle valve interior with short, widely divergent dental adminicula that enclose ventral muscle field anteriorly, commonly flaring anteriorly in large shells to accommodate heavier musculature; subdelthyrial plate or callosity commonly present in large shells; teeth moderately large, oriented nearly parallel to hinge line, blade-like; muscle field deeply impressed, more or less rhomboidal to chordate in outline.

Brachial valve slightly less convex than opposite valve, most convex in umbonal region, sloping evenly to anterolateral margins, moderately compressed near cardinal extremities; dorsal interarea low, acutely triangular, concave, anacline; fold originating in umbonal region as low plication defined by fold-bounding grooves; fold-bounding grooves not readily distinguished anteriorly; fold rising gradually to anterior margin, remaining low and rounded throughout; ornamentation similar to that of opposite valve. Brachial valve interior not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
13448	48.8	+59.3	-
63409	54.3	59.4	-
63410	55.9	66.5	39.2

Type material. Holotype GSC 63410, from GSC locality 57859, Pl. 24, figs. 1-5. Paratypes: GSC 63409, from GSC locality 57859, Pl. 2, fig. 29; GSC 13448, from GSC locality 18527, Pl. 24, fig. 6. This last specimen was illustrated by Harker and Raasch (1958) as *Spirifer* cf. *rowleyi* Weller.

Distinguishing characteristics. This species is characterized by its broad, short, ventral umbo, poorly developed fold and sulcus, transverse subsemicircular outline with alate to mucronate cardinal extremities in juveniles, becoming subquadrate to subsemielliptical with truncated subangular to subrounded cardinal extremities in adults.

Comparisons. Several previous workers (see synonymy list above) have compared this common species to *Spirifer rowleyi* Weller, a well known species found in the Fern Glen Formation and lowermost Burlington Limestone of Missouri, and the Lake Valley Formation of New Mexico. However, *Spirifer rowleyi* differs from this new Banff species in having a narrower, more elongated ventral umbo and strongly developed angular fold and sulcus.

Spirifer mountraensis n. sp. appears to be most similar to *Spirifer grimesi* Hall from the Burlington Limestone and *Spirifer logani* Hall of the Keokuk Formation, both from the midcontinent. *Spirifer grimesi* differs from the Banff species in having a narrower, more elongate ventral umbo, better developed fold and sulcus, and much more elongate outline, with narrowly truncated lateral extremities. Early growth stages of the two appear to be similar and very difficult to differentiate.

Spirifer logani differs from *S. mountraensis* in being larger, having a more transverse subquadrate outline even in large adults, and a much stronger fold and sulcus. As with *S. grimesi*, early growth stages could be readily confused with small *S. mountraensis*. *Spirifer logani* is similar to the Banff species in having a short, broad ventral umbo, wide hinge line, and similar general growth form, and may indeed be closely related.

Distribution. This species is common in the "upper" Banff member of the western facies, ranging throughout the upper two brachiopod zones. It occurs at the following GSC localities: 18527, 57859, 62038, 66349, 69556, 69558, 69559, 69567, 69568, 69572, 74887, 74893, C-4132, C-57471 and C-57474.

Spirifer esplanadensis Brown

Plate 25, figures 1-23; Figure 22

1952 *Spirifer esplanadensis* Brown, p. 64, 97-98, Pl. 5, fig. 1a-e, Textfig. 14.

1961 *Spirifer esplanadensis* Brown. Nelson, Pl. 3, figs. 11-16.

1967 *Spirifer esplanadensis* Brown. Macqueen and Bamber, p. 32, Pl. 1, fig. 4a, b.

1970 *Spirifer esplanadensis* Brown. Bamber, Pl. 12, fig. 7a, b.

Description. Medium size for genus, subequally biconvex, outline subcircular to transversely subovate; greatest width at about mid-length; lateral extremities subangular; fold and sulcus well developed in anterior half of shell; anterior commissure strongly uniplicate; ornament consisting of numerous, fine, low, rounded, bifurcating costae over entire shell, irregularly spaced growth varices, and fine capillae; four or five primary costae nearest sulcus and originating at sides of beak trifurcate within about 1 cm of beak, forming fascicles in umbonal region; other bifurcations occur sporadically over remainder of flanks; median sulcal costa originates at tip of beak, usually bifurcating two or more times; intercostal grooves narrow; shell substance of moderate thickness for genus.

Pedicle valve strongly convex, most inflated in umbonal region, with maximum thickness in posterior third of valve, commonly near hinge line; umbonal region moderately narrow, projecting well beyond hinge line; flanks weakly convex with concave flexures delimiting slightly compressed

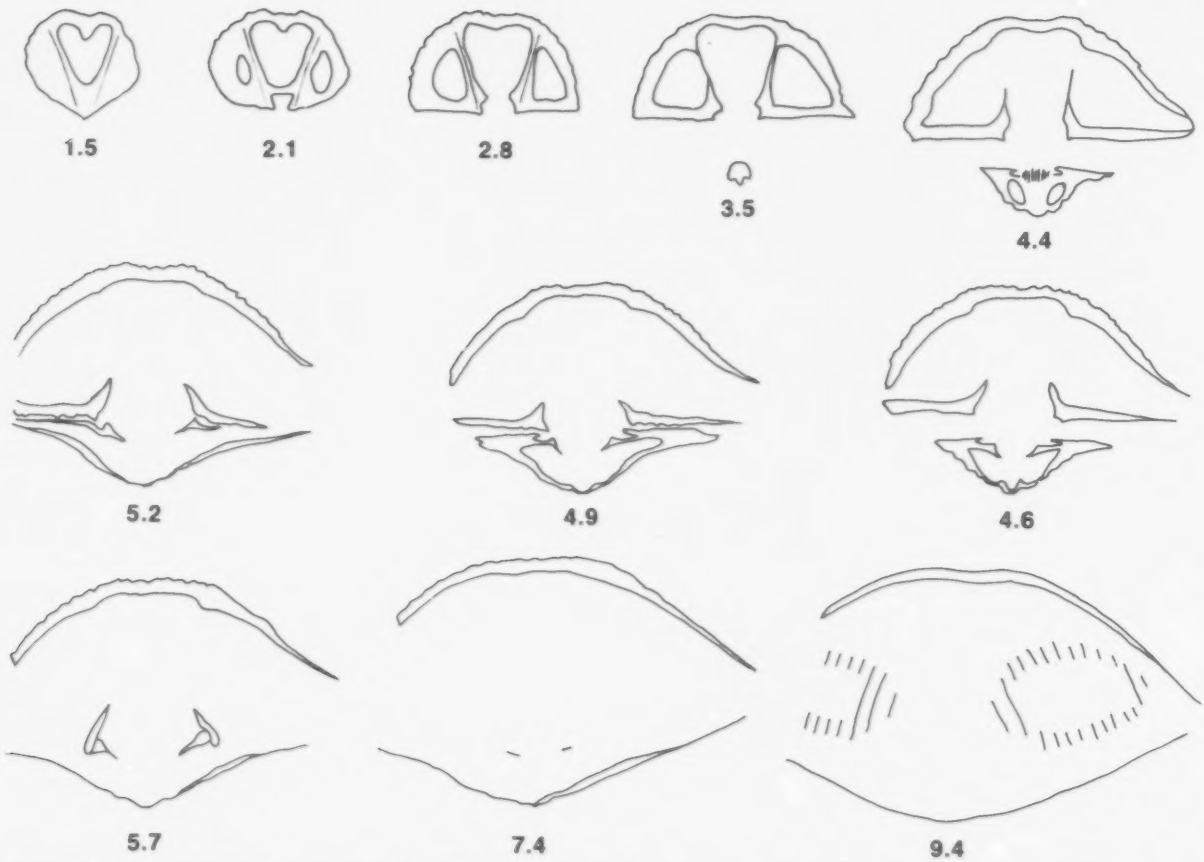

Figure 22. *Transverse serial sections (x2.3) of* ***Spirifer esplanadensis*** *Brown, GSC 63414, from GSC locality 36760. The measurements refer to millimetres from the ventral beak.*

subangular lateral extremities; beak small, pointed, incurved over interarea; beak ridges subangular, well defined; interarea of moderate height, concave, acutely triangular, may be truncated at extremities, vertically grooved, apsacline; hinge line denticulate; delthyrium of about equal height and breadth, apparently open; sulcus originating at beak as shallow groove bounded by two stronger costae, remaining shallow and weakly delimited throughout its length, becoming quite broad anteriorly with moderate tendency to flare anteriorly and incorporating several additional pairs of lateral costae; anteromedial portion of sulcus commonly with weak plication formed by median costa and its derivative costae; sulcus-bounding costae well defined only in beak region, shoulders of sulcus becoming well rounded anteriorly; large tongue produced at front margin.

Pedicle valve interior with moderately stout, short, slightly divergent dental adminicula; short, subdelthyrial plate or callosity formed in large specimens; teeth small; muscle field subelliptical, moderately impressed; other details not observed.

Brachial valve less inflated than pedicle valve, moderately convex in umbonal region and flanks, weakly concave and slightly compressed near cardinal extremities as in opposite valve; dorsal beak inconspicuous; interarea very low, acutely triangular, anacline; fold originating at beak, defined only by fold-bounding grooves, which usually become indistinct by about mid-length; fold rising substantially anterior to mid-length, becoming evenly rounded, commonly flaring in anterior third of valve incorporating several additional pairs of costae; pattern of costae similar to that of opposite valve, that is, several primary costae near fold trifurcate posteriorly forming several fascicles, remainder of surface with scattered bifurcations only.

Brachial valve interior with striate cardinal process posteriorly supported by callus; sockets small, shallow; socket ridges weak; spiralia composed of numerous whorls; adductor field weakly impressed; other internal details not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
9199	37.7	37.8	27.3
9200	34.6	34.3	25.3
9201	29.9	29.8	20.8
63411	33.2	32.6	23.3
63412	28.0	±36.0	24.1
63413	25.2	24.9	15.5

Type material. Holotype GSC 9199, Pl. 25, figs. 1-4. Paratypes: GSC 9200, Pl. 25, figs. 5-8; GSC 9201 and GSC 9202 (neither are illustrated here).

Distinguishing characteristics. This species can be distinguished by its subovate outline, protuberent ventral

umbo, high fold that flares anteriorly, fasciculate primary costae near the umbonal region, and a low, anteromedial plication in the sulcus.

Comparisons. Spirifer esplanadensis is not very similar to other spiriferids in the Banff Formation. It has a similar outline, profile, and shallow sulcus to small specimens of *Spirifer gregeri* Weller from the Chouteau Limestone of the Mississippi Valley region, but can easily be distinguished by its narrower and more elongate ventral umbo, medial plication in the sulcus, and higher fold. There is some tendency for fasciculation of the primary costae in *S. gregeri*, but it is not as well developed as in *S. esplanadensis*.

Spirifer rostellatus Hall, from the Keokuk Limestone of the midcontinent, has a similar outline, size, and narrow elongate umbonal region, and the fold and sulcus tends to flare anteriorly. It differs in having far fewer costae, which are not as flattened as in *S. esplanadensis*, and the fold is much lower anteriorly. In addition, there is no evidence of fasciculation in the umbonal region and the shells are, in general, thinner and less inflated.

Distribution. Spirifer esplanadensis is a very common constituent of the *Calvustrigis rutherfordi* assemblage. It is found in both facies, but is particularly common in the eastern facies, occurring at the following GSC localities: 31350, 36755, 36760, 36777, 37131, 40263, 49692, 49695, 49698, 49699, 49704, 49705, 49706, 49707, 49709, 49710, 49721, 49723, 49726, 49727, 49728, 49731, 49734, 49742, 49754, 49757, 49758, 66038, 66102, 66108, 66113, 66326, 66329, 66332, 68452, 68453, 68455, 68457, 68486, 68487, 68516, 68517, 68518, 68519, 68523, 68567, 74856, 74860, C-4129, C-4130, C-7383 and C-86545. In the western facies, it has been recovered from the following GSC localities: 62087, 62089, 62101 and 74931.

Spirifer cascadensis Warren, 1927

Plate 24, figures 7-10

1927 *Spirifer cascadensis* Warren, p. 58-59, Pl. 7, figs. 1, 2.

1960 *Spirifer cascadensis* Warren. Brindle, p. 92, 94; Pl. 22, figs. 17-19; Pl. 23, figs. 1-8.

1961 *Spirifer cascadensis* Warren. Crickmay, p. 14, Pl. 2, fig. 1.

1961 (?) *Spirifer cascadensis* Warren. Nelson, Pl. 7, fig. 7.

Description. Medium size for genus, unequally biconvex, pedicle valve thicker than brachial valve; outline transversely subsemicircular; greatest width at hinge line; cardinal extremities mucronate in juveniles, becoming alate and subangular in adults; fold and sulcus moderately developed; anterior commissure uniplicate; ornament consisting of numerous well rounded costae, sharply defined by narrow, subangular intercostal furrows, irregularly spaced growth lines, which are subimbricate anteriorly; sulcal ornament consisting of median costa that usually bifurcates once or more, and several pairs of lateral sulcal costae that split from sulcus-bounding costae and which may also bifurcate, giving a total of about seven to twelve sulcal costae; approximately thirty to thirty-four lateral costae in large specimens, commonly bifurcating in umbonal region, rarely on lateral slopes; trifurcations rarely occur in umbonal region; shell substance of moderate thickness for genus.

Pedicle valve moderately inflated, most convex in umbonal region; broad, short; flanks more weakly convex, sloping evenly to anterolateral margins; lateral extremities moderately compressed, delimited by weakly concave flexures; beak small, short, slightly incurved; beak ridges angular, sharply defining interarea; interarea apsacline to nearly orthocline, acutely triangular, flattened to moderately concave, of moderate height, vertically grooved; hinge line denticulate; delthyrium slightly wider than long; deltidal plates not observed; sulcus originating at beak, defined by prominent, subangular, sulcus-bounding costae; anteriorly sulcus remains shallow, rounded, moderately broad, poorly defined, occasionally flaring slightly; median costa and its derivatives may be slightly raised on low plication; sulcus-bounding costae well defined in umbonal region, becoming poorly defined and difficult to distinguish near anterior margin. Pedicle valve interior with stout dental adminicula; other details not observed.

Brachial valve moderately inflated, most convex in umbonal region, maximum thickness attained posterior to mid-length; umbonal region broad, protruding slightly posterior to hinge line; flanks weakly convex, sloping evenly to anterolateral margins; lateral extremities compressed, delimited by concave flexures; beak inconspicuous; dorsal interarea not observed; fold originating as low, narrow plication in umbonal region, well defined to about mid-length by deep, fold-bounding grooves; anteriorly, fold-bounding grooves become shallower, with fold less well defined; fold remaining low and rounded throughout. Brachial valve interior not observed.

Dimensions (mm).

GSC no.	Length	Width	Number of sulcal costae	Number of lateral costae
8909	31.7	± 54.2	8	32
63415	+33.0	± 58.5	± 12	± 30
63416	28.2	58.2	10	32

Type material. Warren selected eight, disarticulated, incomplete valves as syntypes, GSC 8909 and GSC 8909a-g. His illustrations (1927, Pl. 7, figs. 1, 2) are composites drawn from several designated syntypes of the type suite. Warren's two best specimens are illustrated here (Pl. 24, figs. 7, 8). The larger and better preserved of these, a pedicle valve, GSC 8909, was illustrated by Crickmay (1955, Pl. 2, fig. 1) as the holotype, although Warren clearly did not designate a holotype. Crickmay's choice of the best specimen of the type suite for holotype is an obvious one. In order to avoid further confusion, this specimen is here designated as lectotype. The other six paralectotypes are poorly preserved.

Distinguishing characteristics. This species can be differentiated by its subsemicircular outline, alate or subangular lateral extremities, moderately developed fold and sulcus, broad, short ventral umbo, numerous strong, rounded costae, separated by narrow subangular grooves, which bifurcate freely in the umbonal region only, and irregularly spaced subimbricate growth lamellae.

Comparisons. Other Banff spiriferids similar to *S. cascadensis* are *Unispirifer minnewankensis* (Shimer) and *S. mountraensis* n. sp. Large specimens of *Unispirifer minnewankensis* may resemble *S. cascadensis* in outline, degree of fold and sulcus development, lateral profile, and sulcal ornament. *Unispirifer minnewankensis* differs in having far fewer lateral costae with fewer bifurcations. The costae of *U. minnewankensis* are separated by wider, less angular intercostal furrows. Early growth stages of *Spirifer mountraensis* n. sp. may be similar to adult *S. cascadensis* in

general aspect and ornament. They can be distinguished because they have lower, more flattened costae with wider intercostal furrows and, usually, a more subquadrate or less transverse outline.

Warren (1927, p. 59) compared his new species with *Spirifer incertus* Hall from the Burlington Limestone of Iowa. *Spirifer incertus* has strongly and regularly imbricate growth lamellae and a single median sulcal costa. It is probably assignable to the genus *Imbrexia* Nalivkin and may be only superficially similar to *S. cascadensis.*

Spirifer subequalis Hall, from the Keokuk and Warsaw formations of the Mississippi Valley region and southwestern Missouri, is perhaps the North American species most similar to *S. cascadensis.* It possesses a transverse outline with alate extremities and very similar ornamentation. However, it is much more transverse, its brachial valve is relatively more inflated, and its costae are not as narrowly rounded.

Another similar species is *Spirifer shepardi* Weller from the Pierson Limestone of southwestern Missouri. It is close to *S. cascadensis* in outline, development of the fold and sulcus, and ornamentation, but differs in having fewer lateral ribs and a better developed fold and sulcus.

Distribution. Spirifer cascadensis is not a common Banff fossil. It appears to range from the *Calvustrigis rutherfordi* Zone into the *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone, but is known from only seven GSC localities, three from the eastern facies (49688, 49734 and 49738), and four from the western facies (69554, C-57469, C-57470 and C-86543).

Genus *Podtsheremia* Kalashnikov, 1966

Podtsheremia? *albertensis* (Warren), 1932

Plate 22, figures 9-27; Figure 23

1932 *Spirifer albertensis* Warren, in Allan, Warren and Rutherford, p. 244-245, Pl. 1, figs. 7-14.

Description. Medium size for genus, subequally biconvex, moderately inflated; outline transversely subsemiovate; greatest width at hinge line; lateral extremities subangular to widely mucronate in all observable growth stages; fold and sulcus well developed, moderately narrow; anterior commissure uniplicate; entire surface costate with approximately fifteen to nineteen costae on flanks, usually fifteen or sixteen; and about five to eleven costae in sulcus, usually six to eight; two primary lateral costae near sulcus bifurcate, rarely one or three; occasionally one primary costa trifurcates; median sulcal costa commonly bifurcates; other sulcal costae split from sulcus-bounding costae or, rarely, also bifurcate once; all costae and intercostal furrows are strongest and most angular posteriorly, becoming lower and more rounded anteriorly; growth varices irregularly spaced; micro-ornament consists of fine capillae and faint, evenly spaced growth lines; shell substance impunctate, of moderate thickness.

Pedicle valve most convex in umbonal region, moderately inflated; maximum thickness attained posterior to mid-length; umbonal region moderately swollen but not elongate; flanks weakly convex, becoming slightly concave laterally; lateral extremities slightly compressed; beak small, incurved over interarea; beak ridges angular, sharply defined; interarea concave, of moderate height, acutely triangular, vertically grooved, apsacline; hinge line denticulate; delthyrium apparently open, width approximately equal to height; sulcus originating at beak as a groove, becoming gradually wider, deeper, and more evenly rounded anteriorly, defined posteriorly by strong, subangular bounding costae, which become more rounded and less prominent anteriorly; dental adminicula well developed, short, not greatly thickened, meeting dental flanges at low angle; teeth small; muscle field moderately impressed; subdelthyrial plate or callus short.

Brachial valve moderately and evenly convex in lateral profile or may be more strongly convex in dorsal umbonal region; umbonal region not swollen appreciably; flanks evenly and weakly convex except near lateral extremities, where they become weakly concave and slightly compressed; dorsal beak inconspicuous; interarea low, slightly concave, apsacline; fold originating at beak as prominent costa flanked by deep, intercostal furrows, becoming moderately high and well defined anteriorly, rounded to subcarinate anteriorly; cardinalia and articulatory structures relatively delicate for family; cardinal process striate, splitting into two lobes anteriorly; crural bases originating dorsal to cardinal process but not forming tabellae; socket ridges weak, thin; crura directed dorsomedially; spiralia composed of numerous whorls; muscle field and myophragm not observed in sectioned specimens.

Dimensions (mm).

Specimen	Length	Width	Thickness
GSC 63417	28.5	+36.0	-
GSC 63418	21.9	+31.4	15.7
GSC 63419	19.4	+28.7	16.1
UA Cb 281	18.7	+25.2	+11.5
UA Cb 285	25.0	+25.0	14.6

Type material. Warren's syntype suite of eight specimens are in the collections of the University of Alberta, Edmonton, numbers Cb 279-283, 285-287. The best of these syntypes are illustrated here (Pl. 22, figs. 9-27).

Distinguishing characteristics. This species can be differentiated by its transverse subsemiovate outline, subangular to mucronate lateral extremities, two bifurcating (or trifurcating) primary lateral costae on each flank, commonly bifurcating median sulcal costa, about fifteen or sixteen lateral costae, and about six to eight costae in the sulcus.

Comparisons. Podtsheremia? *albertensis* (Warren) is most similar to *Spirifer missouriensis* Swallow from the Chouteau Limestone of Missouri. The Banff species can be readily differentiated by its smaller number of bifurcating lateral costae, usually having two, only one of which may trifurcate. *Spirifer missouriensis* usually has at least three, and commonly four, bifurcating lateral costae, more than one of which may trifurcate. It also tends to have slightly more numerous costae on both the flanks, and fold and sulcus. Otherwise the two species are very similar and intergrade in almost every parameter.

Remarks. The generic assignment of this species is tentative because the type species, and other Russian and Western European species assigned by Kalashnikov (1966, p. 51; 1974, p. 113-118) to this genus, possess rounded lateral extremities in all growth stages. The ornamentation of *P.*? *albertensis* is so similar to that of *P. prima* Kalashnikov, the type species, that the Banff species is assigned here to Kalashnikov's genus with reservations, as in Roberts (1971, p. 217).

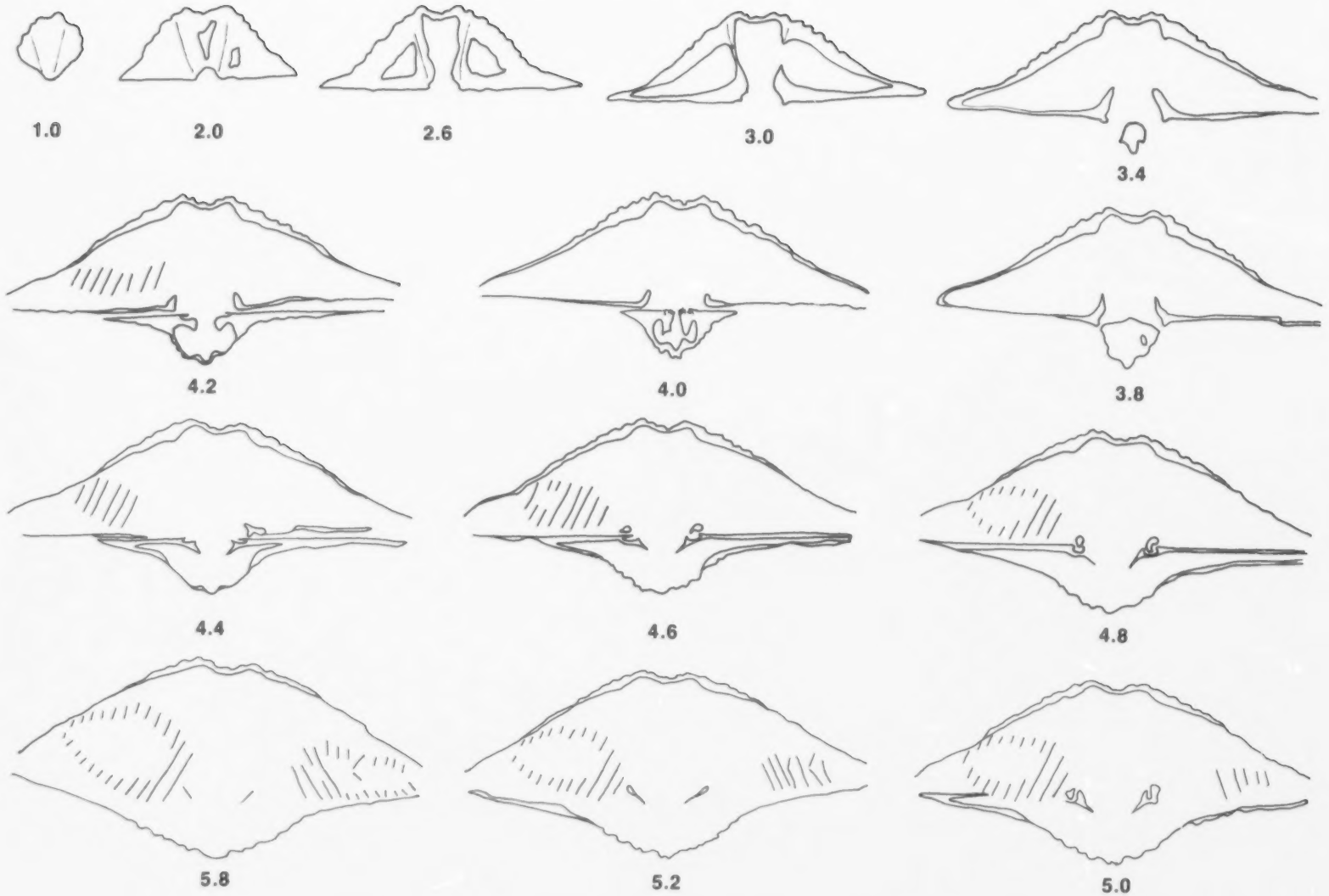

Figure 23. *Transverse serial sections (x3) of* ***Podtsheremia?*** ***albertensis*** *(Warren), GSC 63420, from GSC locality 49695. The measurements refer to millimetres from the ventral beak.*

Distribution. This genus appears to be restricted to the *Calvustrigis rutherfordi* Zone of the eastern facies, and is very common. It has been identified in collections from the following GSC localities: 18788, 49688, 49690, 49695, 49704, 49705, 49706, 49707, 49709, 49723, 49735, 49740, 49750, 49752, 49756, 66038, 68458, 68459, 68522, C-4130 and C-86545.

Family BRACHYTHYRIDIDAE Frederiks, 1924

Genus *Brachythyris* M'Coy, 1844

Brachythyris chouteauensis (Weller), 1909

Plate 26, figures 7, 8

1909 *Spirifer chouteauensis* Weller, p. 305-306, Pl. 13, fig. 11.

Remarks. The pedicle valves illustrated in Plate 26 and assigned to Weller's well known species are similar in most respects to authentic specimens from several horizons and localities in the midcontinent, although neither of the Banff specimens is complete. The largest illustrated specimen, a pedicle valve from GSC locality 73526 ("upper" member, western facies), has a deeper sulcus than is usual, although it clearly falls within the range of variation known for *B. chouteauensis.* The other illustrated specimen, a pedicle valve from GSC locality 49721 (*Calvustrigis rutherfordi* Zone, eastern facies), is typical in most respects, although the umbonal region is somewhat narrower and more elongate than is usual for *B. chouteauensis.*

Other specimens referred to this species are from GSC localities 36787, 49698, 49719 and 68567.

Brachythyris cf. *B. chouteauensis* (Weller)

Plate 26, figures 9-14

Description. Smaller than average for genus, subequally biconvex, pedicle valve slightly thicker than brachial valve; outline transversely subovate; greatest width attained near or slightly posteriorly to mid-length; lateral extremities well rounded; fold and sulcus moderately developed, of moderate width; anterior commissure uniplicate; ornament consisting of broadly rounded, low, simple costae separated by equally wide, rounded intercostal furrows, several irregularly spaced growth varices, and fine, regularly spaced growth lines; sulcal costae consist of strong median costa that originates in beak region and two, weaker, lateral sulcal costae that bifurcate from sulcus-bounding costae; approximately eleven costae on each flank of lateral slopes, becoming weaker and indistinct near lateral extremities; shell substance impunctate, thin.

Pedicle valve moderately inflated, most convex in umbonal region; maximum thickness attained normal to or slightly anterior to hinge line; lateral slopes moderately convex, sloping evenly to anterolateral margins; lateral extremities slightly compressed, defined by weakly concave flexures; beak small, narrow, incurved over delthyrium; beak ridges subangular or weakly rounded, moderately defined, delimiting low, acutely triangular, weakly concave, apsacline interarea; hinge line apparently nondenticulate; width of delthyrium approximately equal to height, partially occluded by thin posteriorly projecting deltidial plates; sulcus originating in beak as a groove, shallow and rounded throughout, attaining moderate breadth at anterior commissure, producing small, subsemicircular tongue.

Pedicle valve interior very simple, with low, rounded dental flanges supporting sides of delthyrium and teeth; teeth of moderate size, blade-like; muscle field with no impression, and indistinguishable in transverse section.

Brachial valve slightly less inflated than opposite valve, most convex posteromedially but evenly and moderately convex on lateral slopes; cardinal extremities very slightly compressed as in opposite valve; umbonal region narrow, slightly protuberant, beak inconspicuous; dorsal interarea very low, acutely triangular, anacline; fold originating at beak as low narrow costa, rising moderately above lateral slopes anteriorly, sharply delimited by disproportionately deep fold-bounding furrows, becoming slightly flattened anteriorly, ornamented by four indistinct costae.

Brachial valve interior very simple with unsupported, striate, cardinal process; inner socket ridges low, narrow; crural bases medially concave, attached to inner edges of inner socket ridges, directed dorsomedially, becoming moderately broad anteriorly; spiralia composed of about eleven whorls; adductor impressions not observed in transverse section.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63423	15.8	19.9	11.4

Type material. GSC 63423, from GSC locality C-11787, Pl. 26, figs. 9-14.

Remarks. The above description is based on a complete specimen from GSC locality C-11787. A brachial valve from GSC locality 49721 appears to be conspecific.

Compared with typical *Brachythyris chouteauensis* from the midcontinent, the described specimen is too small, too transverse, its ventral umbonal region is too short and narrow, and its lateral extremities are too broad. Perhaps more significantly, the median sulcal costa is decidedly convex and well defined. In typical *B. chouteauensis,* the median sulcal region may be delimited by two furrows but a raised rounded median costa is rarely, if ever, formed. For these reasons it is not possible to identify these specimens positively.

Genus *Skelidorygma* Carter, 1974

Skelidorygma bamberi n. sp.

Plate 26, figures 1-6

1974 *Skelidorygma* n. sp. A. Carter, Pl. 4, figs. 5-7, 13, 14.

Description. Moderate size for genus, pedicle valve moderately convex; outline subcircular to transversely subovate; greatest width attained at about mid-length; lateral extremities rounded; sulcus shallow, rounded, poorly defined; anterior commissure uniplicate; ornament consisting of numerous, simple, flattened, strap-like costae separated by narrow intercostal furrows, weak, irregularly spaced growth varices, and fine, sinuous, irregularly spaced growth lines; sulcus with five simple costae, including median costa that originates at beak, and two pairs of lateral sulcal costae that originate by splitting from sulcus-bounding costae

twelve to seventeen costae on lateral slopes, those of lateral extremities very faint; shell substance of moderate thickness, impuncate.

Pedicle valve most inflated in umbonal region but almost evenly convex in lateral profile; lateral slopes less convex, sloping steeply to anterolateral commissure; lateral extremities slightly compressed, defined by slightly concave flexures; beak small, narrow, slightly incurved over apex of delthyrium; beak ridges very poorly developed; interarea obscurely defined, weakly concave, slightly wider than high, apsacline; width of delthyrium approximately equal to height, partially occluded by deltidial plate at sides and apex.

Pedicle valve interior lacking dental adminicula; strong dental flanges supporting teeth present; muscle field moderately incised; adductor scars narrow and elongate, extending well forward of diductors; diductors narrow, elongate, enclosing posterior portion of adductors; obscure impressions of numerous radial pallial marks on flanks.

Brachial valve unknown.

Dimensions (mm).

GSC no.	Length	Width	Number of ribs
10063	46.9	+42.0	29
63424	+24.0	+32.0	27
63425	+36.0	+43.0	37

Type material. Holotype GSC 63424, from GSC locality C-4132, Pl. 26, figs. 1-4. Paratypes GSC 10063, from GSC locality 18527, Pl. 26, fig. 5; GSC 63425, from GSC locality C-4132, Pl. 26, fig. 6.

Distinguishing characteristics. This species is characterized by a poorly defined sulcus with five sulcal costae and twelve to seventeen simple, strap-like lateral costae separated by narrow, intercostal furrows.

Comparisons. The type species of this genus, *Skelidorygma subcardiiformis* (Hall), from the Warsaw and Salem formations of the midcontinent, can be readily distinguished by its much coarser costae and better developed sulcus.

Skelidorygma laticosta (Mather), from the Morrow Formation of Oklahoma, is similar to *S. subcardiiformis* and can be distinguished in the same manner.

Skelidorygma kaindensis (Gladchenko), from the Tournaisian of the Kirgiz S.S.R, like *S. subcardiiformis* and *S. laticosta*, has much coarser ornamentation than *S. bamberi* n. sp. In addition, it is probably much more inflated than *S. bamberi*, although uncrushed, complete specimens of the latter have not yet been discovered.

Skelidorygma bamberi n. sp. is most similar and perhaps related to *Brachythyris atbasarica* Nalivkin from the Viséan of Kazakhstan. The latter species is huge, reaching a maximum dimension of 12 to 15 cm, has an even less well defined sulcus with fewer sulcal costae, and a few more numerous lateral costae. As for *S. bamberi*, only the pedicle valve of the Soviet species is known.

Distribution. This species is known from only five GSC localities: C-4132, 18527, 49719, 66115 and 69565. The first three collections are from "upper" Banff horizons, western facies, the last two from the *Calvustrigis rutherfordi* Zone, eastern facies. All of these collections consist of incomplete pedicle valves.

Derivation of name. This species is named in honour of E.W. Bamber, who was mainly responsible for its recovery from the Tunnel Mountain Section of the Bow River.

Superfamily RETICULARIACEA Waagen, 1883

Family ELYTHIDAE Frederiks, 1924

Genus *Torynifer* Hall and Clarke, 1894

Torynifer pseudolineatus (Hall), 1858

Plate 27, figures 12-16

1858 *Spirifer pseudolineatus* Hall, p. 645, Pl. 20, fig. 4.

Remarks. Several small collections of this well known species from the "upper" member of the western facies compare very closely with authentic specimens from the Burlington Limestone of the midcontinent, and with the description and illustrations given by Weller (1914, p. 429, Pl. 74, figs. 1-11). Some of the Banff specimens are less transverse than usual for the species, but other specimens from the same bed have the typical, transverse outline one normally associates with *T. pseudolineatus*.

Distribution. "Upper" member, *Stegacanthia* cf. *S. bowsheri-Marginatia ferrglenensis* Zone, GSC localities C-57471 and 18527; *Avonia minnewankensis-Marginatia burlingtonensis* Zone, GSC localities 62041, 68593 and C-57468; "upper" member, unzoned, GSC localities 18293 and 69567. A single specimen from GSC locality 66038, *Calvustrigis rutherfordi* Zone, appears to be assignable to this species.

Torynifer eufastigium n. sp.

Plate 27, figures 1-11; Figure 24

Description. Medium size for genus, moderately and subequally biconvex; outline transversely subelliptical; greatest width attained slightly posterior to mid-length; lateral extremities well rounded; fold and sulcus moderately developed, well delimited from flanks; anterior commissure uniplicate; ornament consisting of growth lamellae almost regularly spaced, anteriorly fringed with very fine, double-barrelled spines; shell substance thin, impunctate.

Pedicle valve most convex in umbonal region, gently convex on lateral slopes, sloping evenly to lateral margins; umbonal region of moderate width, not projecting much beyond dorsal umbo; beak small, incurved; lateral extremities well rounded, slightly compressed posteriorly; beak ridges subangular, moderately well defined; interarea of moderate height, acutely triangular, gently concave, apsacline to almost catacline, vertically grooved; hinge line finely denticulate; width of delthyrium approximately equal to height, partly occluded by thin, narrow deltidial plates; sulcus shallow, rounded, moderately narrow, originating in beak region, moderately well defined; dental adminicula well developed, stout, diverging to follow sulcal margins, extending forward about one fourth to one third of valve length; median septum very low, originating in beak region, extending forward almost to ends of dental adminicula; teeth small, blade-like; numerous, straight, radiating, pallial impressions on inner surface give impression of weak costae on spalled shells.

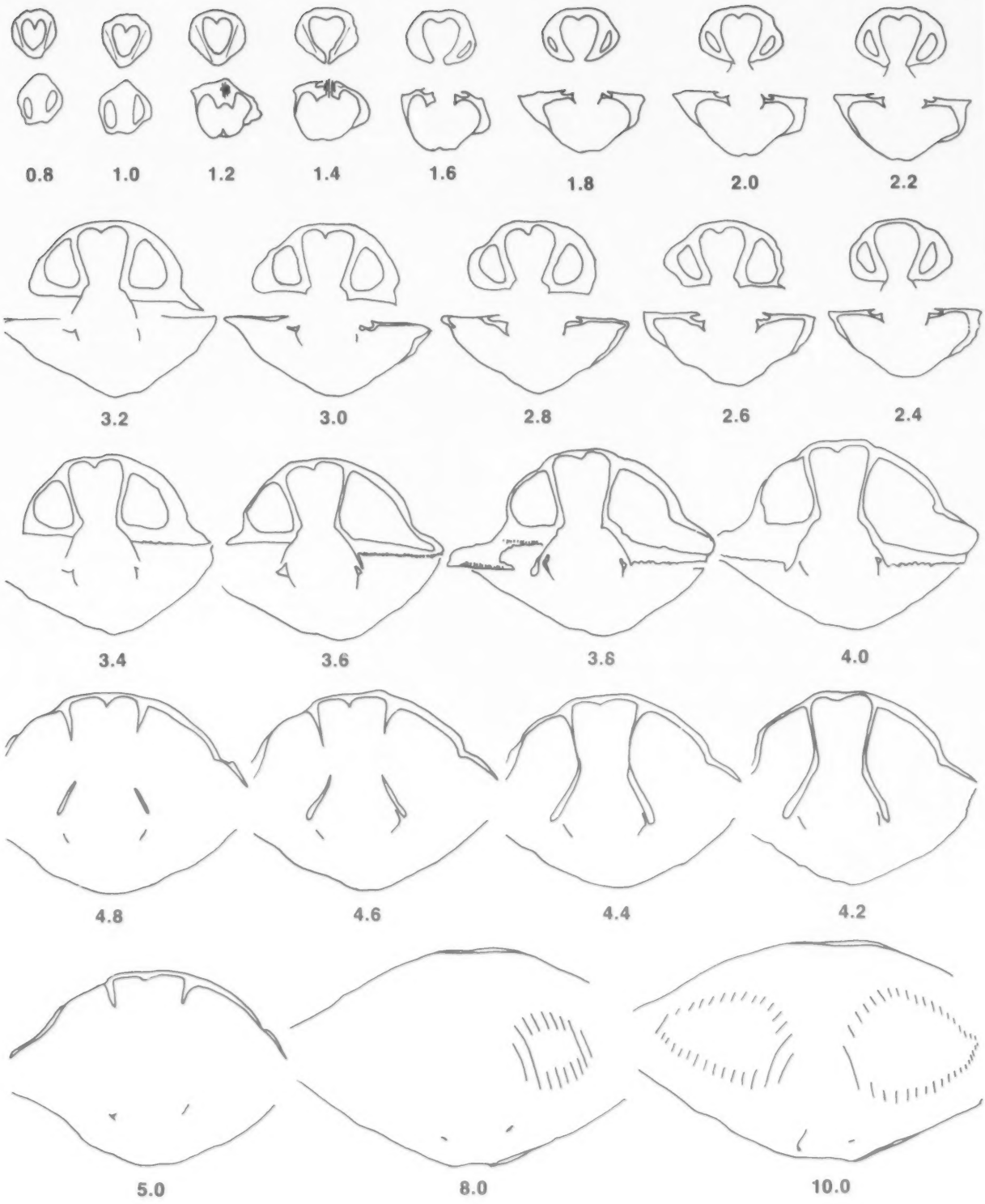

Figure 24. *Transverse serial sections (x2.3) of* ***Torynifer eufastigium*** *n. sp., GSC 63431, from GSC locality 49746. The measurements refer to millimetres from the ventral beak.*

Brachial valve about as thick as pedicle valve, most convex in umbonal region, weakly convex on lateral slopes and sloping evenly to lateral margins; lateral extremities slightly compressed; beak inconspicuous; interarea low, moderately concave, orthocline, acutely triangular; fold well rounded, originating in umbonal region, well defined, rising gradually and becoming moderately pronounced in anterior third of valve; radial pallial markings on spalled valves similar to those of opposite valve; cardinal process small, narrow, striate, supported by low, stout, short median ridge; inner and outer socket ridges thin; sockets narrow, short; crural bases nearly vertical, attached to medial edges of inner socket ridges; crura forming slender ribbons that descend near floor of valve before rising to form helical spiralia; spiralia composed of numerous whorls; adductor field not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63428	27.6	34.3	19.1
63429	24.0	29.9	15.7
63430	29.0	36.7	-

Type material. Holotype GSC 63428, from GSC locality 68486, Pl. 27, figs. 1-5. Paratypes: GSC 63429, from GSC locality 49729, Pl. 27, figs. 6-10; GSC 63430, from GSC locality 18559, Pl. 27, fig. 11.

Distinguishing characteristics. This species can be differentiated by its transversely subelliptical outline, well delineated fold and sulcus, and very short, thick, median ridge supporting the cardinalia.

Comparisons. Torynifer eufastigium n. sp. is not very similar to other Lower Mississippian species in North America. It can be readily distinguished from *Torynifer pseudolineatus* (Hall) and *Kitakamithyris cooperensis* (Swallow) by its well defined fold and sulcus. *Torynifer montanus* Shaw, from the Madison Formation of Montana, is smaller, less transverse, has a narrower, more elongate beak, and a less well defined fold and sulcus.

Torynifer setigera (Hall), of Chesterian age, is similar to *Torynifer eufastigium* n. sp. in having a well defined fold and sulcus, but is much less transverse with a subovate outline, and internally it has a long dorsal septum or median ridge.

Remarks. Brown (1952, p. 103) proposed a new variety of *Torynifer pseudolineatus* (Hall), *T. pseudolineatus* var. *jasperensis*, without a description, illustrations, or reference to types. Brown stated that his new variety differs from *T. pseudolineatus* (Hall) in having "more sharply rounded sides, a definite pedicle sinus and brachial fold, and a smaller cardinal area." However, these characters are not diagnostic of the new species described here, which differs from *T. pseudolineatus* and other Lower Mississippian species mainly by its well defined fold and sulcus and its very short dorsal septum or ridge. Furthermore, there are no specimens labeled *Torynifer pseudolineatus* var. *jasperensis* in Brown's collections. Brown did not indicate a type locality for his new variety, making selection of a neotype very difficult. Without the types, description, labeled specimens, or indication of a type locality, it seems wisest to treat *Torynifer pseudolineatus* var. *jasperensis* Brown as a *nomen dubium.*

Distribution. Torynifer eufastigium n. sp. has been found only in collections from the *Calvustrigis rutherfordi* Zone of the eastern facies. It occurs in modest numbers in collections from the following GSC localities: 18559, 49690, 49692, 49695, 49698, 49704, 49705, 49711, 49746, 68486, 68516, 68518, 68519, 68523, C-4130.

Genus *Kitakamithyris* Minato, 1951

Kitakamithyris cooperensis (Swallow), 1860

Plate 27, figures 17-26

1860 *Spirifer cooperensis* Swallow, p. 643.

Remarks. This species is rare in the upper beds of the Banff Formation of the eastern facies. The two complete specimens illustrated here are very similar in every external detail to specimens in collections of this well known species from the midcontinent. A low, weak median ridge is apparent on the brachial valves of the Banff specimens but there is no indication of a true septum supporting the cardinalia as in *Torynifer pseudolineatus* (Hall). For this reason, this species is assigned to the genus *Kitakamithyris* Minato.

Distribution. All of the Banff specimens of this species were recovered from the *Calvustrigis rutherfordi* Zone of the eastern facies, GSC localities 31350, 49688, 49709, C-7388, C-86542, C-86543 and C-86544.

Family MARTINIIDAE Waagen, 1883

Genus *Eomartiniopsis* Sokolskaya, 1941

Eomartiniopsis rostrata (Girty), 1899

Plate 2, figure 30; Plate 27, figures 27-42; Figure 25

1899 *Martinia rostrata* Girty, p. 553-554, Pl. 70, fig. 5a-g.

1972 *Eomartiniopsis rostrata* (Girty). Carter, p. 487-488, Pl. 2, figs. 1-11; Textfig. 6.

Remarks. The description given by Carter (1972) applies equally well to the Banff Formation specimens except for the following additions and emendations.

There is great variation in the size and shape of this species, and the largest specimens known from the Banff Formation are substantially larger than average for the genus (see Pl. 2, fig. 30). The development of a ventral sulcus is extremely variable, virtually lacking in some specimens and moderately well developed in others. The ventral interarea, usually not well preserved, is fairly sharply defined by subangular beak ridges and is vertically grooved, suggesting weak, surficial denticulation similar to that found in the Elythidae. One or two specimens appear to have narrow deltidial plates, also similar to those found in some elythid genera. The dorsal interarea is low, weakly concave, and orthocline. The fold is always better developed than the ventral sulcus and an anteriorly protruding tongue is commonly developed. Internally, almost the entire surface of each valve is covered with numerous, fine, straight radiating pallial markings.

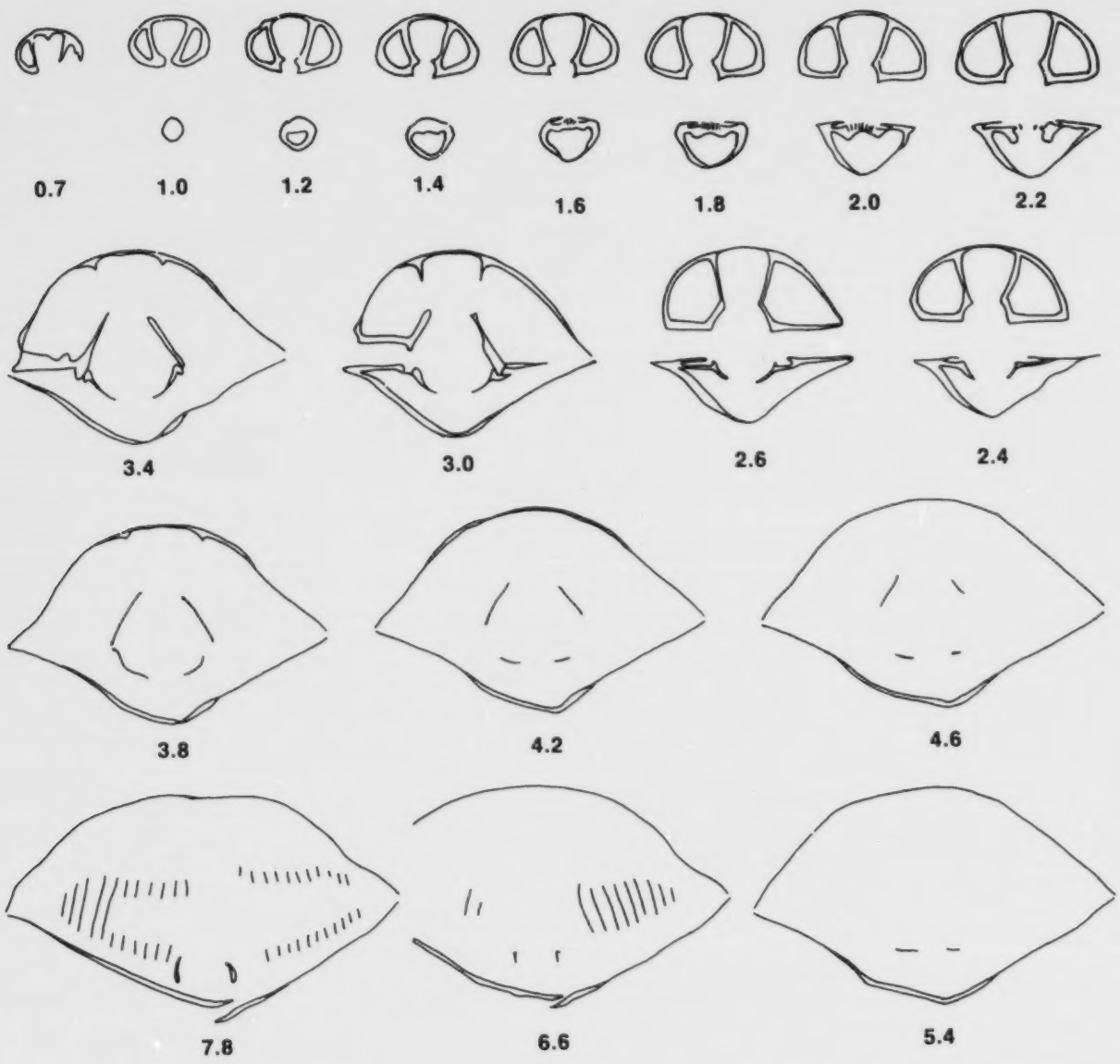

Figure 25. *Transverse serial sections (x2.3) of* ***Eomartiniopsis rostrata*** *(Girty), GSC 63438, from GSC locality 36777. The measurements refer to millimetres from the ventral beak.*

Dimensions (mm).

GSC no.	Length	Width	Thickness
63434	31.8	34.5	21.2
63435	28.0	31.8	18.0
63436	28.7	29.8	20.7
63437	23.7	26.1	17.1
63439	+44.9	+48.5	-

Type material. Girty's syntypes are in the collections of the National Museum of Natural History, Washington, D.C., U.S.A.

Distribution. Eomartiniopsis rostrata (Girty) occurs fairly commonly in the *Calvustrigis rutherfordi* Zone of the eastern facies at GSC localities 18533, 36777, 49692, 66327, 68459, 68521, 68522, 68523, 68567, 74866, C-4129, C-4130, C-86543 and C-86545. In the western facies, it also occurs in this zone at Lake Minnewanka (GSC loc. 62087). Its highest occurrence is in the basal *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone at the Jura Creek section (GSC loc. C-57469).

Order SPIRIFERINIDA Ivanova, 1972

Suborder SPIRIFERINIDINA Ivanova, 1972

Superfamily SPIRIFERINACEA Davidson, 1884

Family SPIRIFERINIDAE Davidson, 1884

Genus *Punctospirifer* North, 1920

Punctospirifer cf. *P. subtexta* (White), 1862

Plate 22, figures 30-32

1892 *Spiriferina? subtexta* White, p. 25.

Remarks. Several Banff Formation specimens appear to be comparable to this well known species, originally described from the Burlington Limestone of the midcontinent. These Banff specimens have six or seven, strong, simple costae on each flank, a narrow, well developed fold and sulcus, and they lack a sulcal costa or fold groove, although there is a faint medial deflection in the growth lines at the anterior parts of the fold and sulcus. *Punctospirifer subtexta*, as described by Weller (1914), usually has six to nine costae per flank, is slightly more transverse, but perhaps most significantly, has a narrower, more elongate ventral beak than is found in these Canadian specimens. Unfortunately, the Banff species has been recovered from only two localities, GSC localities 18527 and C-57469, both from the *Stegacanthia* cf. *S. bowsheri-Marginatia fernglenensis* Zone. Until more specimens become available, exact identification of this Banff form will have to be tentative.

Punctospirifer solidirostris (White), 1860

Plate 22, figures 28, 29, 33, 34

1860 *Spirifer solidirostris* White, p. 232.

Remarks. This species is a common element of the *Calvustrigis rutherfordi* assemblage of the eastern facies, although it is not usually found in large numbers. The Banff specimens agree in all external respects with authentic specimens from the midcontinent.

Allan, Warren and Rutherford (1932, p. 239), Brown (1952, p. 103), and Nelson (1960, Pl. 5, fig. 19) previously reported this species from the Jasper Park region.

Distribution. Eastern facies: *Calvustrigis rutherfordi* Zone, GSC localities 36760, 36777, 49706, 49719, 49727, 49728, 49731, 66115, 68448, 68449, 68455, 68456, 68519, 68567, 74858, 74931, C-4129, C-4130, C-7382 and C-7388. Western facies: *Calvustrigis rutherfordi* Zone, GSC localities 69548, 69550 and 73521.

Family SYRINGOTHYRIDIDAE Frederiks, 1926

Genus *Syringothyris* Winchell, 1863

Syringothyris cf. *S. hannibalensis* (Swallow), 1860

Plate 28, figures 13-22

1860 *Spirifer* (*Cyrtia*?) *hannibalensis* Swallow, p. 647.

Description. Medium size for genus, strongly biconvex, pedicle valve subpyramidal and much thicker than brachial valve; outline transversely subovate to subquadrate; position of greatest width varying from hinge line almost to mid-length; lateral extremities subangular to rounded; fold and sulcus well developed, of moderate breadth, noncostate; anterior commissure uniplicate; ornament consisting of about sixteen to twenty, usually nineteen, simple, flattened costae on each flank that become progressively finer laterally, and coarse, irregularly spaced growth varices; finer ornament not observed; shell substance punctate.

Pedicle valve variable in thickness and height of interarea, usually of moderate thickness for genus; lateral slopes moderately convex, sloping evenly to anterolateral margins; beak small, slightly overhanging interarea in most specimens; beak ridges subrounded to subangular, rarely angular; cardinal extremities not compressed or well delimited; interarea flattened, commonly slightly convex at apex, catacline to procline, rarely less than 60 degrees from plane of lateral commissure; delthyrium of moderate breadth, usually about half of height; delthyrial cover not observed; sulcus of moderate breadth and depth, usually evenly concave, rarely slightly flattened; subdelthyrial plate well below plane of interarea, about one third of height of interarea; syrinx sharply pointed, extending dorsally well beyond subdelthyrial plate; dental plates short, following shoulders of sulcus; well developed myophragm present in some specimens; other internal details not observed.

Brachial valve moderately inflated, most convex umbonally; lateral slopes curving evenly to anterolateral margins; cardinal extremities slightly compressed in some specimens, evenly convex in others; beak inconspicuous to moderate in size, moderately incurved; dorsal interarea low, concave, acutely triangular, inclination indeterminate in specimens available; fold well defined, originating in beak region, rising gradually toward front of valve, attaining moderate height, well rounded throughout; cardinal process supported by short median septum; other internal details not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness	Height of interarea
63443	34.0	45.9	29.2	20.5
63444	25.1	36.3	25.2	19.1

Type material. Swallow's types were destroyed by fire at the University of Missouri.

Discussion. Although this Banff Formation species is similar and comparable to *Syringothyris hannibalensis* (Swallow) it differs from typical Louisiana Limestone specimens in having a shallower sulcus, lower fold, slightly fewer ribs, and a less procline, possibly even catacline, ventral interarea.

Rodriguez and Gutschick (1967, p. 376) described and illustrated *S. hannibalensis* from the Sappington Formation of Montana. This species does not appear to be conspecific with the Banff specimens. The Sappington species has a distinctly concave ventral interarea, a blunt syrinx, and the costae appear to be slightly finer and more numerous.

In some respects, this Canadian species is comparable to *Syringothyris newarkensis* Weller from the Chouteau Limestone of Missouri. However, the Missouri species has compressed, angular, lateral extremities in both valves, very sharp beak ridges, and a narrower delthyrium.

Syringothyris typa Winchell from the Burlington Limestone of Iowa has a similar outline, lateral profile,

shallow sulcus, low fold, catacline to moderately procline ventral interarea, and the fairly broad delthyrium characteristic of the Banff species. It differs mainly in being substantially larger, has more numerous ribs, a more concave ventral interarea, and more convex lateral slopes on the pedicle valve.

These Banff Formation specimens probably represent an undescribed species, but the collections available are too poorly preserved to permit the confident diagnosis of a new taxon.

Distribution. Eastern facies: *Calvustrigis rutherfordi* Zone, GSC localitites 31367, 36777, 37131, 40263, 49695, 49707, 49711, 49730, 49734, 49756, 66038, 68448, 68523, C-7382, C-7388, C-11787, C-86542 and C-86543. Western facies: *Calvustrigis rutherfordi* Zone, GSC localities 62101, 69555 and 73521.

Genus *Verkhotomia* Sokolskaya, 1963

Verkhotomia jucunda n. sp.

Plate 28, figures 1-12

Description. Medium size for genus, subequally biconvex, pedicle valve thicker than brachial valve; outline transversely subelliptical; maximum width attained at or near hinge line; lateral extremities subrounded to subangular or slightly alate; fold and sulcus well developed, rounded, bald; anterior commissure uniplicate; ornament consisting of about fifteen to seventeen, flattened, rounded, simple costae (distal ones very faint) and strong, irregularly spaced growth varices; micro-ornament not preserved on specimens available; shell substance punctate and of moderate thickness.

Pedicle valve most convex in umbonal region, maximum thickness attained posteriorly, approximately at right angles to hinge line; umbonal region very broad, not well delimited from flanks and umbo; beak ridges subangular, sharply defining interarea; interarea moderately high, concave, acutely triangular, apsacline; delthyrium narrowly triangular, higher than wide, delthyrial cover not observed; sulcus originating in beak region as narrow shallow groove, becoming broader and deeper anteriorly, with rounded shoulders and bottom throughout; subdelthyrial plate depressed only slightly below plane of interarea posteriorly near beak, becoming somewhat deeper anteriorly, extending forward about half of length of delthyrium; dental adminicula very long, diverging very little, remaining inside or medial to shoulder of sulcus, extending forward to mid-length or slightly anterior to mid-length; adductor muscle field located on raised, rounded, elongate elevations in apical cavity between dental adminicula; diductor field large, weakly striated longitudinally, laterally enclosing anterior portion of adductor scars.

Brachial valve moderately inflated, most convex in umbonal region; lateral slopes moderately convex, curving evenly to lateral margins; cardinal extremities slightly compressed, delimited by weakly concave flexures; beak small, inconspicuous, slightly incurved; dorsal interarea very low, concave, orthocline or slightly inclined to plane of lateral commissure; fold well defined throughout length of valve, originating in beak region as low, rounded plication, gradually becoming broader and higher anteriorly, producing moderate lingual extension with sulcus, defined posteriorly by disproportionately deep, fold-bounding grooves; cardinal process composed of numerous longitudinal plates, supported anteriorly by short, thick, median septum and laterally by stout inner socket ridges fused with crural bases; brachidial details not observed; adductor field weakly impressed with weak, low myophragm.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63445	44.0	+70.3	32.7
63446	41.6	±59.0	31.5

Type material. Holotype GSC 63446, from GSC locality 57859, Pl. 28, figs. 6-9. Paratypes: GSC 63445, from GSC locality C-57470; Pl. 28, figs. 1-5; GSC 63447 and 63448, from GSC locality C-4132, Pl. 28, figs. 11, 12.

Distinguishing characteristics. This species is characterized by its moderate size, transversely subelliptical outline, subangular, extended cardinal extremities, incurved beak with concave ventral interarea, very low dorsal interarea, fifteen to seventeen costae per flank, narrow delthyrium, and shallow, subdelthyrial plate.

Comparisons. Other North American species similar to *Verkhotomia jucunda* n. sp. are *Verkhotomia plena* (Hall) and *V. latior* (Weller) from the Burlington Limestone of the mid-continent, and *Verkhotomia calvini* (Weller) from the Hampton Formation and Gilmore City Limestone of central Iowa.

Verkhotomia plena differs from this new species in being larger and proportionately longer, with well rounded cardinal extremities and beak ridges, wider delthyrium, and a broader ventral beak. Immature specimens of *V. plena* are quite similar to mature *V. jucunda*, but can be recognized by their rounded lateral extremities. *Verkhotomia latior* can be distinguished by its rounded cardinal extremities, broader delthyrium, more numerous costae, less incurved ventral beak, and more deeply depressed subdelthyrial plate. *Verkhotomia calvini* also has more rounded cardinal extremities than this Banff species, and, in addition, has fewer costae, a wider delthyrium, shorter subdelthyrial plate, shorter dental adminicula, and a longer dorsal median septum.

Verkhotomia verkhotomica Sokolskaya from the Viséan of the Kuznets Basin is similar in outline to this mid-Tournaisian Banff species. It differs in having a very broad delthyrium and a flatter, less concave ventral interarea. In addition, Sokolskaya (1963, p. 285, figs. 123, 125) presents drawings that illustrate a high dorsal interarea and a long, slender, median septum in the brachial valve.

Distribution. This species is known only from the "upper" member of the western facies. It occurs commonly in both zones of the "upper" member at the following GSC localities: C-57470, C-57471, *Stegacanthia* cf. *S. bowsheri-Marginatia ferneglenensis* Zone; 60998, 62038, 62041, 66349, 68593, 69558, 69560, 69572, 74893, 74895 and C-57468, *Avonia minnewankensis-Marginatia burlingtonensis* Zone; 57859, 69567, C-4132 and C-57474, unzoned "upper" member.

Order TEREBRATULIDA Waagen, 1883

Suborder TEREBRATULIDINA Waagen, 1883

Superfamily CRYPTONELLACEA Thomson, 1926

Family CRANAENIDAE Cloud, 1942

Subfamily CRANAENINAE Cloud, 1942

Genus *Cranaena* Hall and Clarke, 1893

Cranaena cf. *C. texana* Carter, 1967

Plate 29, figures 24-38; Figure 26

1967 *Cranaena texana* Carter, p. 425-428, Pl. 44, figs. 1a-10e; Textfig. 48.

Discussion. A few specimens of this rare species have been found at several Banff Formation localities. Most of these Banff specimens agree externally with specimens from several Chappel Limestone collections, but internally they are distinctly different. One complete individual was transversely sectioned. The interior of this specimen, diagrammatically illustrated in Figure 26, was coarsely recrystallized, but the internal structures are well preserved. The dental plates in this specimen are longer and more medially placed than those in the specimen figured by Carter (1976, Textfig. 48). Most significantly, the hinge plate is almost flat and the transverse band of the loop is highly arched and posteriorly acute. In *Cranaena texana*, the hinge plate is strongly concave and the transverse band is weakly arched and rounded.

This Upper Kinderhookian to early Osagean species is externally characterized by its small size, tumid profile, and moderately broad ventral umbonal region, with the maximum width attained near or posterior to mid-length. The last characteristics allow this species to be distinguished from the slightly older and less tumid *Cranaena occidentalis* (Miller) from the Chouteau Limestone of Missouri, and from the slightly younger and more tumid *Cranaena globosa* Weller from the Burlington Limestone of the midcontinent. These three species are probably closely related and they have a certain number of morphological similarities.

One specimen figured here (Pl. 29, figs. 34-38) has a weak ventral sulcus and is slightly emarginate, but most probably is the same species. Some of the sulcal depression may be due to postmortem lateral compression.

Unfortunately, there are too few Banff specimens suitable for sectioning in order to confirm the unusual nature of the loop.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63449	10.5	8.2	6.0
63450	10.8	8.4	5.9
63451	10.7	7.7	6.8

Distribution. Eastern facies: *Calvustrigis rutherfordi* Zone, GSC localities 19992, 49707, 49727, 49740, 68567, 74866, C-4130 and C-86545. Western facies: *Calvustrigis rutherfordi* Zone GSC locality 62101.

Superfamily DIELASMATACEA Schuchert, 1913

Family DIELASMATIDAE Schuchert, 1913

Genus *Dielasma* King, 1859

Dielasma sp. A

Plate 29, figures 15-18; Figure 27

Description. Medium size for genus, subequally biconvex; outline subtrigonal to subchordate; greatest width attained in anterior third of shell; lateral profile lenticular; anterior commissure weakly uniplicate; broad, shallow sulcus in pedicle valve and narrow, very shallow sulcus in brachial valve, producing slightly emarginate front margin; ornament lacking except for a few, irregularly spaced, coarse growth varices and very fine growth lines; punctae densely packed.

Pedicle valve most convex in umbonal region, attaining maximum thickness slightly posterior to mid-length; lateral slopes gently convex; umbonal region moderately broad; beak and foramen not preserved; beak ridges subrounded, defining concave palintropes; delthyrium occluded by flattened deltidial plates; sulcus originating posterior to mid-length, remaining shallow throughout; dental plates short, slightly divergent.

Brachial valve most convex in umbonal region, lateral slopes moderately convex, slightly flattened laterally; lateral profile weakly convex; umbonal region slightly tumid; beak small, projecting into delthyrial cavity; sulcus originating in umbonal region, remaining shallow and narrow throughout; interior with tiny cardinal boss at apex of beak; hinge plates converging medially to meet at floor of valve; crural bases originating about two thirds along hinge plates from floor of valve; crural processes high, slightly converging ventrad; descending branches of loop at right angles to plane of commissure, diverging slightly; transverse band, strongly arched ventrad, broadly V-shaped in transverse view.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63452	15.8	13.1	8.2

Remarks. The foregoing description is based on a single, nearly complete specimen from GSC locality 37131.

Although the generic appelation *Dielasma* has been liberally applied by a variety of authors over the years, the author knows of only two non-Banff authentic Lower Mississippian *Dielasma* in North America, an unnamed species described by Carter (1967, p. 437) from the Chappel Limestone of central Texas and the species identified as *Dielasma* cf. *D. utah* (Hall and Whitfield) from the Lodgepole Limestone of Montana by Rodriguez and Gutschick (1968, p. 1031). By virtue of its broad ventral umbo and weak dorsal sulcus, the specimen available undoubtedly represents an undescribed species, but the lack of more specimens hinders the establishment of a new species. Comparison of *Dielasma* sp. A with another undescribed representative of this genus can be found below.

Dielasma sp. B

Plate 29, figures 19-23; Figure 28

Description. Small for genus, subequally biconvex; outline guttate; greatest width attained in anterior third of shell;

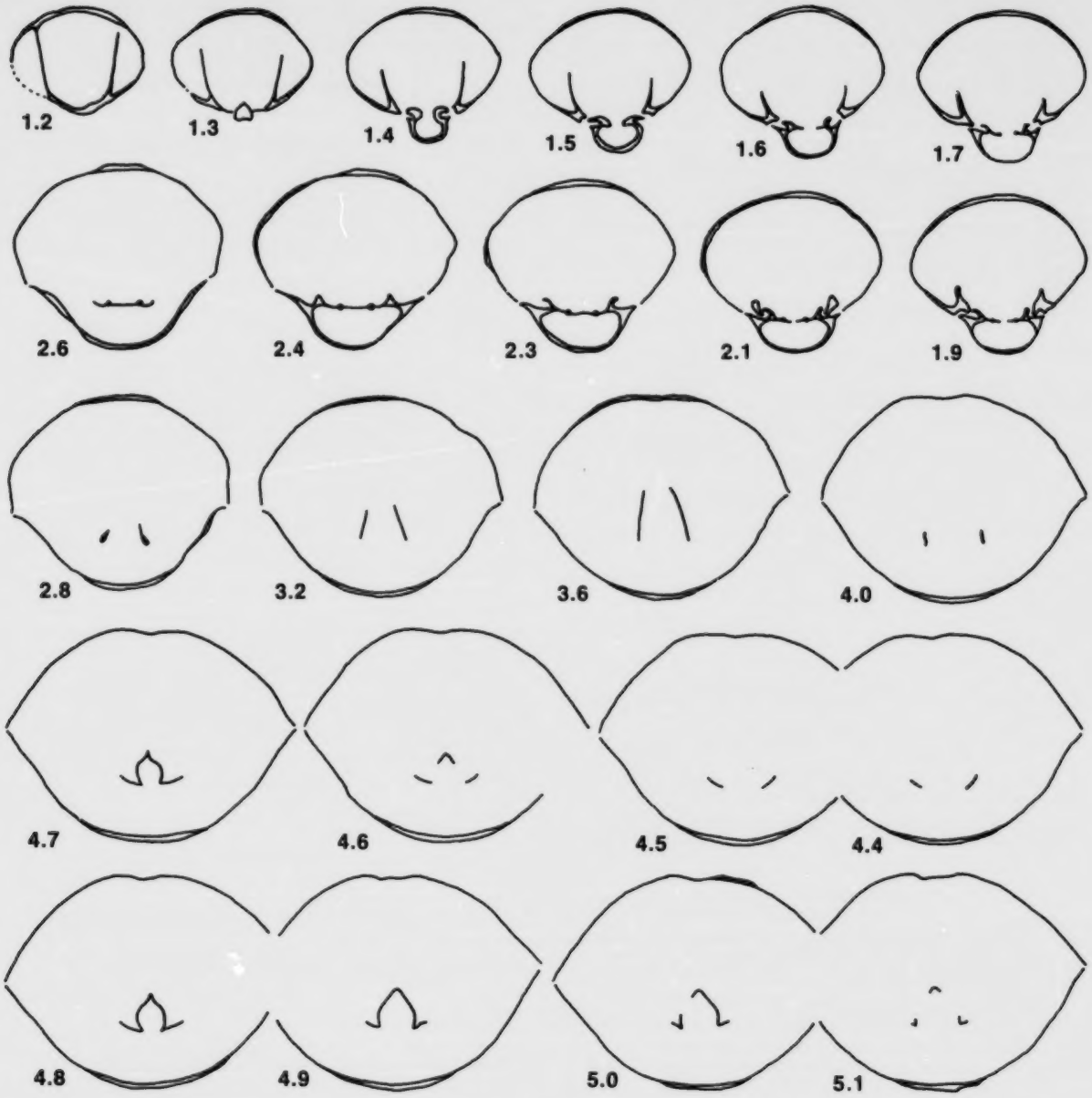

Figure 26. *Transverse serial sections (x6) of* ***Cranaena*** *cf.* ***C. texana*** *Carter, GSC 63449, from GSC locality C-4130. The measurements refer to millimetres from the ventral beak.*

lateral profile sublenticular; anterior commissure rectimarginate; fold and sulcus lacking; anterior margin evenly rounded; ornament apparently lacking except for a few coarse growth varices and fine growth lines.

Pedicle valve most convex in umbonal region, with maximum thickness attained approximately at right angles to hinge line; lateral slopes and venter evenly convex except for flattening of venter near anterior commissure; umbonal region elongate and moderately narrow; beak suberect; foramen probably permesothyridid; beak ridges subrounded, poorly defining slightly concave, elongate palintropes; delthyrium occluded by flattened deltidial plates; dental plates thin and well developed, diverging slightly at floor of valve, extending forward well into umbonal region; pedicle collar complete but short.

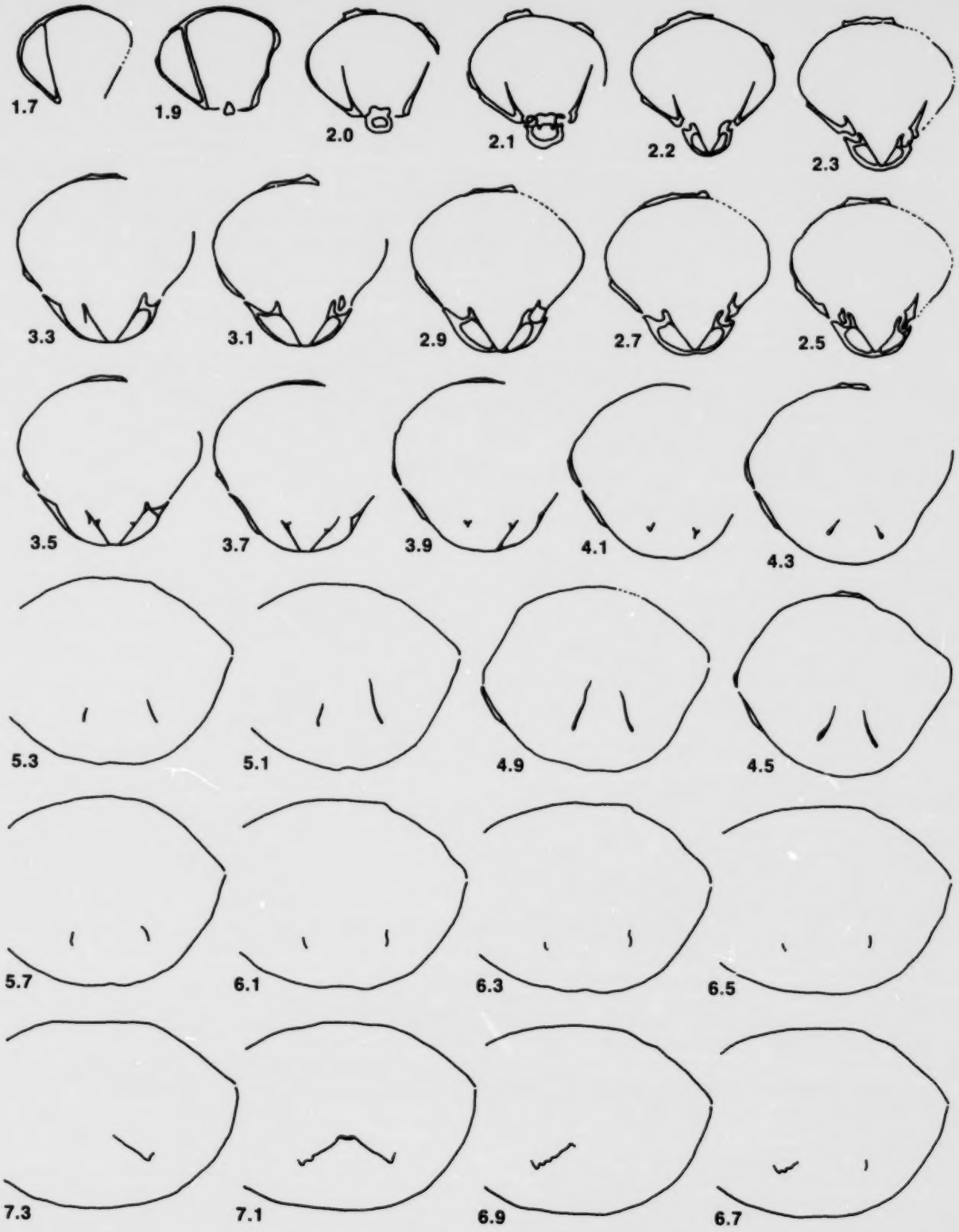

Figure 27. *Transverse serial sections (x4.5) of* ***Dielasma*** *sp. A, GSC 63452, from GSC locality 37131. The measurements refer to millimetres from the ventral beak.*

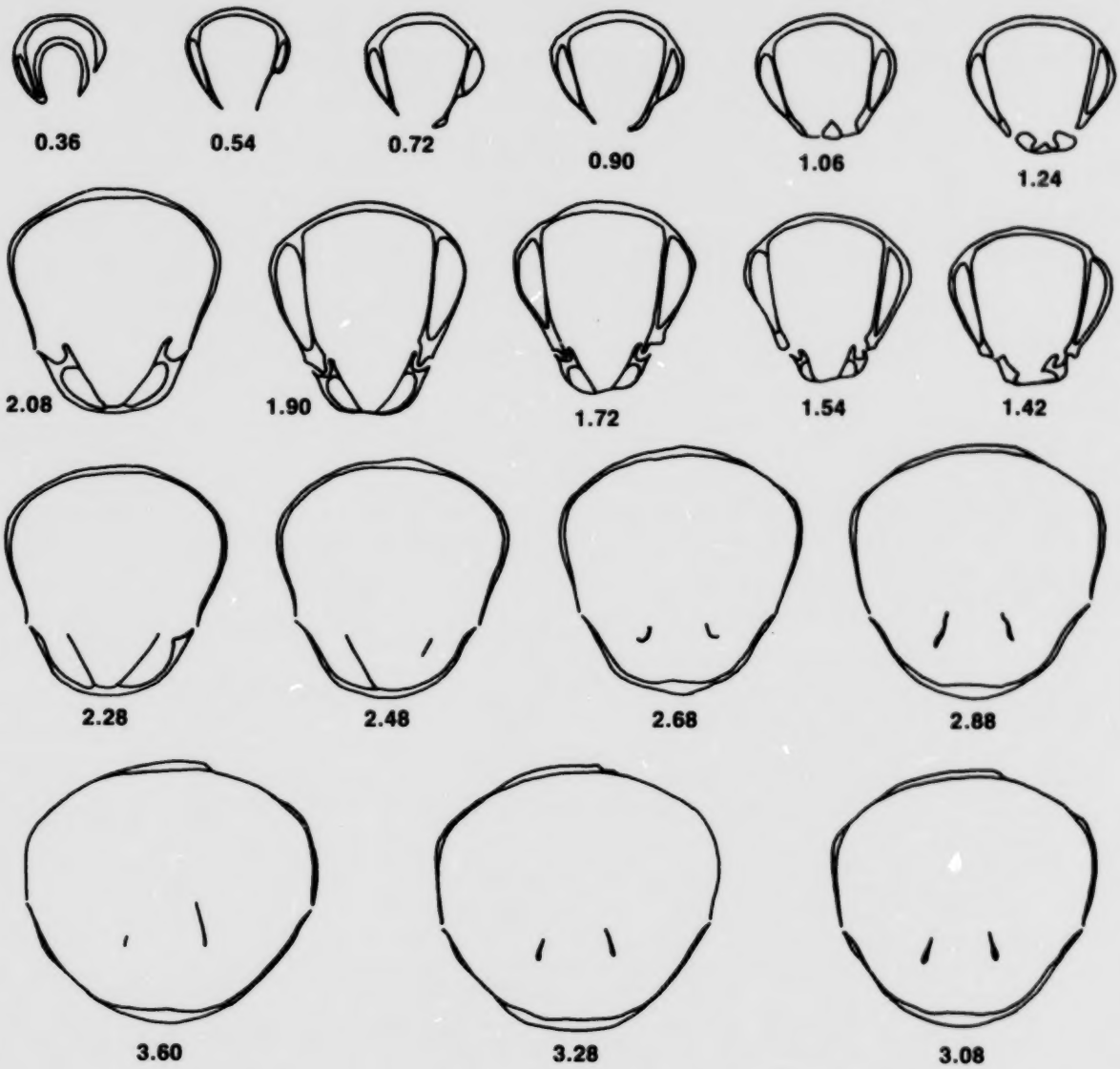

Figure 28. *Transverse serial sections (x9) of* ***Dielasma*** *sp. B, GSC 63453, from GSC locality 68573. The measurements refer to millimetres from the ventral beak.*

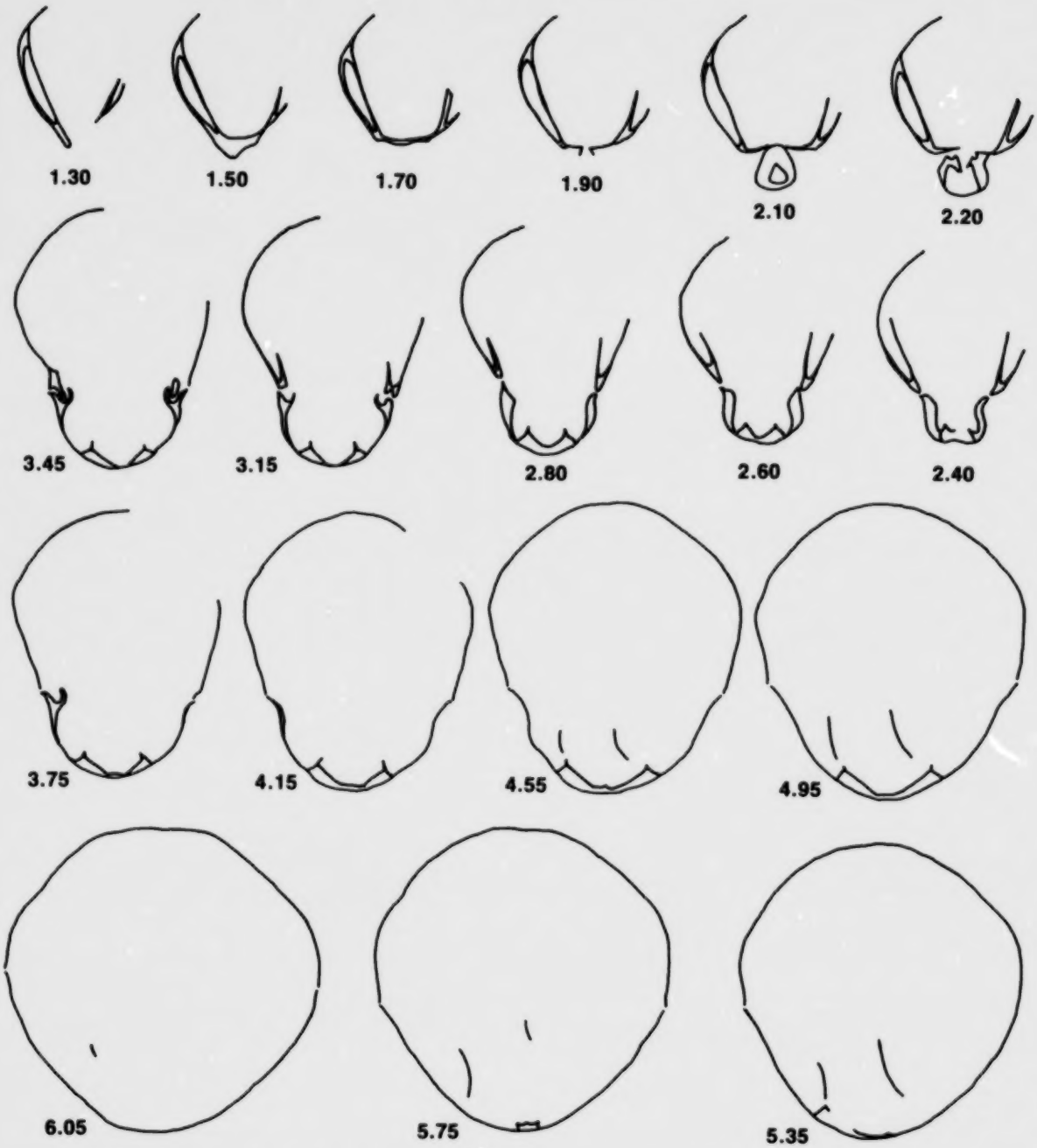

Figure 29. *Transverse serial sections (x6) of* ***Beecheria chouteauensis*** *(Weller), GSC 63455, from GSC locality 66117. The measurements refer to millimetres from the ventral beak.*

Brachial valve most convex in umbonal region; lateral slopes and dorsum moderately and almost evenly convex, becoming slightly less convex anteriorly; umbonal region slightly tumid; beak small, projecting into delthyrial cavity; interior with hinge plates converging but not joining medially at floor of valve; outer hinge plates about half as wide as inner hinge plates; inner socket ridges high, thin, merging with outer hinge plates in transverse view; crura developed as U-shaped processes, becoming flattened, vertical bands anteriorly; crural processes flattened in transverse view, slightly medially inclined; transverse band of loop not observed.

Dimensions (mm).

GSC no.	Length	Width	Thickness
63453	9.6	7.2	4.6

Remarks. The description given above is based on a single, small, complete specimen from GSC locality 68573. The narrow elongate ventral umbo and lack of a definite sulcus in either valve suggest that this specimen is taxonomically distinct from the specimen described above as *Dielasma* sp. A. The small size of the specimen at hand suggests that it is probably not mature despite the well developed dental plates in the pedicle valve. Unfortunately, the loop was not completely preserved.

Family HETERELASMINIDAE Likharev, 1956

Genus ***Beecheria*** Hall and Clarke, 1893

Beecheria chouteauensis (Weller), 1914

Plate 29, figures 1-14; Figure 29

1914 ***Dielasma chouteauensis*** Weller, p. 257-259, Pl. 32, figs. 1-17, Textfig. 29.

Diagnosis. Medium sized *Dielasma* with subequally biconvex, moderately compressed valves, subovate outline, evenly convex, lenticular anterior profile, rectimarginate anterior commissure, rounded front margin, and occasionally faintly costellate ornament. Internally, the hinge plates unite posteriorly and tend to rise slightly off the floor of the valve.

Type material. Weller's syntype suite is in the collections of the Field Museum of Natural History, Chicago, U.S.A., numbers UC 8547, UC 9666, UC 9703, and UC 12237. The first of these (UC 8547) is from the Pierson Limestone of southwestern Missouri (early Osagean age) and the other three are from the Chouteau Limestone of central Missouri (middle to late Kinderhookian age).

Remarks. Most of the Banff specimens assigned to this species differ very little from typical Chouteau Limestone specimens. However, the specimens referred to in Plate 29, figs. 9-14 as *Beecheria* cf. *B. chouteauensis* (Weller) have a somewhat broader ventral umbo than authentic *B. chouteauensis* specimens from Missouri.

Distribution. Well preserved specimens of this species are rare. It occurs in small numbers most commonly in the *Calvustrigis rutherfordi* Zone of the eastern facies, GSC localities 18790, 49707, 66038, 66177, 66330, 68570 and C-86543. In the "upper" member of the western facies it has been recovered from three GSC localities: 18293, 60997 and C-57468.

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APPENDIX 1

GSC localities and stratigraphic positions of brachiopod collections from the Banff Formation

GSC locality	Stratigraphic section	Location	Formation	Stratigraphic position
18293	Mt. Rundle	51°09'N, 115°30'W	Banff	500 ft. (155 m) above base (a.b.)
18527	Sunwapta Pass, east side	52°13'N, 117°10'W	Banff	300-400 ft. (91-122 m) below top (b.t.)
18550	Mt. Coleman, Jasper area	52°07'N, 116°55'W	middle Banff	uncertain
18553	Palisade Summit	52°59'N, 118°08'W	Banff	uncertain
18555	Morro Creek	53°01'30"N, 118°04'W	Banff	200 ft. (61 m) b.t.
18558	Mt. Greenock (Windy Pt.)	53°05'30"N, 118°03'30"W	upper Banff	uncertain
18559	Morro Creek	53°01'30"N, 118°04'W	Banff	135 ft. (41 m) b.t.
18788	Morro Creek	53°01'30"N, 118°04'W	Banff	15 ft. (5 m) b.t.
18790	Morro Creek	53°01'30"N, 118°04'W	Banff	195 ft. (59 m) b.t.
18852	Mt. Norquay	51°10'30"N, 115°38'W	Banff	uncertain
18861	Mt. Norquay	51°10'30"N, 115°38'W	upper Banff	near base
19992	Medicine Lake, south end	52°50'N, 117°43'W	Banff; upper part of unit 3	uncertain
31347	Miette map area	53°07'N, 118°01'W	upper Banff	uncertain
31349	Miette map area	uncertain	upper Banff	uncertain
31350	Miette map area	uncertain	upper Banff	uncertain
31367	Roche à Perdrix, west side	53°12'30"N, 117°48'W	Banff	uncertain
36755	Miette Hotsprings	53°08'N, 117°44'W	Rundle	uncertain
36760	Ridge east of Sphinx Creek	53°04'N, 117°32'W	Banff	uncertain
36770	Miette Hotsprings	53°08'N, 117°44'W	upper Banff	top of Banff Formation
36777	Head Slide Creek, Miette area	53°04'N, 117°42'W	upper Banff	uncertain
36782	Lower Fiddle River, Miette area	53°12'N, 117°51'W	Banff	uncertain
36787	Fall Creek, Fiddle River, Miette area	53°03'30"N, 117°39'W	middle Banff	uncertain
36801	Section Creek, Fiddle River	53°03'N, 117°42'W	lower Rundle Group	uncertain
40263	Wolf Pass Trail, west of Moosehorn Lakes, Rock Lake area, Mt. Robson map sheet	uncertain	upper Banff	uncertain
49688	Morro Creek, north valley wall	53°03'N, 118°04'W	upper Banff	113.5 ft. (35 m) b.t. (Brown, 1952, p. 48)
49690	Athabasca Point	53°02'15"N, 118°05'W	Banff	106 ft. (32 m) b.t. (Brown, 1952, Fig. 13)

GSC locality	Stratigraphic section	Location	Formation	Stratigraphic position
49692	Mt. Esplanade, east flank, south end	53°03'30"N, 118°07'15"W	upper Banff	244 ft. (74 m) b.t. (Brown, 1952, Fig. 13)
49695	Athabaska Point	53°02'15"N, 118°05'W	Banff	106 ft. (32 m) b.t. (Brown, 1952, Fig. 13)
49698	Windy Point	53°05'N, 118°03'30"W	Banff	254 ft. (77 m) b.t. (Brown, 1952, p. 36)
49699	Mt. Esplanade, talus, east flank, south end	53°03'30"N, 118°07'15"W	upper(?) Banff	244 ft. (74 m) b.t. (Brown, 1952, Fig. 13)
49704	Athabasca Point, talus	53°02'15"N, 118°05'W	upper Banff	106 ft. (32 m) b.t. (Brown, 1952, Fig. 13)
49705	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	120 ft. (37 m) b.t. (Brown, 1952, p. 36)
49706	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper(?) Banff	190 ft. (58 m) b.t. (Brown, 1952, Fig. 11)
49707	Cobblestone Creek, east bank	53°03'30"N, 118°07'30"W	upper Banff	170 ft. (52 m) b.t. (Brown, 1952, p. 52)
49709	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	190 ft. (58 m) b.t. (Brown, 1952, Fig. 11)
49710	Mt. Esplanade, east flank, south end	53°03'30"N, 118°07'15"W	upper Banff	250 ft. (76 m) b.t. (Brown, 1952, Fig. 13)
49711	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	middle Banff	268 ft. (82 m) b.t. of Banff (Brown, 1952, Fig. 11)
49714	Athabasca Point	53°02'30"N, 118°05'W	upper Banff	10 ft. (3 m) b.t. (Brown, 1952, Fig. 13)
49719	Grassy Ridge	53°04'30"N, 118°06'W	upper Banff	52 ft. (16 m) b.t. (Brown, 1952, Fig. 12)
49720	Grassy Ridge, southwest spur	53°04'30"N, 118°06'30"W	upper Banff	115 ft. (35 m) b.t. (Brown, 1952, p. 41)
49721	Mt. Esplanade	53°04'N, 118°08'W	upper Banff	202 ft. (62 m) b.t. (Brown, 1952, Fig. 13)
49722	Mt. Esplanade	53°04'N, 118°08'W	upper Banff	202 ft. (62 m) b.t. (Brown, 1952, Fig. 13)
49723	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	20 ft. (6 m) b.t. (Brown, 1952, p. 36)
49726	Mt. Esplanade, top	53°04'30"N, 118°09'W	Rundle Group	297 ft. (90 m) a.b. (Brown, 1952, p. 51)
49727	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	190 ft. (58 m) b.t. (Brown, 1952, Fig. 11)
49728	Mt. Greenock, junction of Windy Pt. and forestry road	53°05'N, 118°03'30"W	upper Banff	190 ft. (58 m) b.t. (Brown, 1952, Fig. 11)
49729	Cobblestone Creek, west side	53°03'30"N, 118°07'30"W	Rundle Group	223 ft. (68 m) a.b. (Brown, 1952, p. 51)
49730	Mt. Esplanade	53°04'N, 118°08'W	upper Banff	223 ft. (68 m) b.t. (Brown, 1952, Fig. 13)
49731	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	190 ft. (58 m) b.t. (Brown, 1952, p. 11)

GSC locality	Stratigraphic section	Location	Formation	Stratigraphic position
49733	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	254 ft. (77 m) b.t. (Brown, 1952, p. 36)
49734	Grassy Ridge	53°04'30"N, 118°06'W	upper Banff	283 ft. (86 m) b.t. (Brown, 1952, p. 41)
49735	Mt. Esplanade	53°04'N, 118°08'W	upper Banff	53 ft. (16 m) b.t. (Brown, 1952, Fig. 13)
49736	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	72.5 ft. (22 m) b.t. (Brown, 1952, p. 36)
49737	Mt. Esplanade	53°04'N, 118°08'W	lower Banff	425 ft. (130 m) b.t. of Banff (Brown, 1952, Fig. 13)
49738	Mt. Esplanade, east flank, south end	53°03'N, 118°07'15"W	upper Banff	250 ft. (76 m) b.t. (Brown, 1952, Fig. 13)
49740	Mt. Esplanade	53°04'N, 118°08'W	upper Banff	53 ft. (16 m) b.t. (Brown, 1952, Fig. 13)
49741	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	255 ft. (78 m) b.t. (Brown, 1952, p. 36)
49742	Mt. Esplanade, east flank, south end	53°03'N, 118°07'15"W	upper Banff	250 ft. (76 m) b.t. (Brown, 1952, Fig. 13)
49744	Cobblestone Creek, east bank	53°03'30"N, 118°07'15"W	upper Banff	170 ft. (52 m) b.t. (Brown, 1952, Fig. 13)
49746	Mt. Esplanade	53°04'N, 118°08'W	upper Banff	250 ft. (76 m) b.t. (Brown, 1952, Fig. 13)
49750	Cobblestone Creek	53°03'30"N, 118°07'30"W	upper Banff	170 ft. (52 m) b.t. (Brown, 1952, Fig. 13)
49751	Mt. Esplanade, east flank, south end	53°03'N, 118°07'15"W	upper Banff	250 ft. (76 m) b.t. (Brown, 1952, Fig. 13)
49752	Mt. Esplanade, east flank. south end	53°03'N, 118°07'15"W	upper Banff	250 ft. (76 m) b.t. (Brown, 1952, Fig. 13)
49753	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	72.5 ft. (22 m) b.t. (Brown, 1952, p. 36)
49754	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	190 ft. (58 m) b.t. (Brown, 1952, Fig. 11)
49756	Mt. Esplanade	53°04'N, 118°08'W	upper Banff	53 ft. (16 m) b.t. (Brown, 1952, Fig. 13)
49757	Mt. Greenock	53°05'N, 118°03'30"W	upper Banff	54 ft. (16 m) b.t. (Brown, 1952, p. 36)
49758	Mt. Esplanade	53°04'N, 118°08'W	Rundle Group	297 ft. (90 m) a.b. (Brown, 1952, p. 51)
49759	Mt. Greenock (Windy Pt.)	53°05'N, 118°03'30"W	upper Banff	268 ft. (82 m) b.t. (Brown, 1952, Fig. 11)
57859	Picklejar Lakes	50°31'42"N, 114°46'W	upper Banff	47-50 ft. (14-15 m) b.t.
59140	Headwaters, Panther River	51°28'N, 115°48'W	Banff	160-170 ft. (49-52 m) b.t.
60995	Lake Minnewanka	51°15'N, 115°28'W	Banff	273-282 ft. (83-86 m) b.t.

GSC locality	Stratigraphic section	Location	Formation	Stratigraphic position
60997	Lake Minnewanka	51°15'N, 115°28'W	Banff	210-214 ft. (64-65 m) b.t.
60998	Lake Minnewanka	51°15'N, 115°28'W	upper Banff	178 ft. (54 m) b.t.
62038	Grotto Mountain	51°03'N, 115°14'W	upper Banff	180 ft. (55 m) b.t.
62040	Grotto Mountain	51°03'N, 115°14'W	upper Banff	160 ft. (49 m) b.t.
62041	Grotto Mountain	51°03'N, 115°14'W	upper Banff	140 ft. (43 m) b.t.
62087	Lake Minnewanka	51°15'N, 115°28'W	top of middle Banff	300 ft. (91 m) b.t. of Banff (talus)
62088	Lake Minnewanka	51°15'N, 115°28'W	upper Banff	220 ft. (67 m) b.t. (talus)
62089	Lake Minnewanka	51°15'N, 115°28'W	upper Banff	198 ft. (60 m) b.t.
62101	Jura Creek	51°05'N, 115°10'W	uppermost beds of lower Banff	655-660 ft. (200-201 m) b.t. of Banff
62107	Jura Creek	51°05'N, 115°10'W	upper Banff	90-97 ft. (27-30 m) b.t.
62111	Spray Creek	50°59'N, 115°21'W	Banff	473 ft. (144 m) b.t.
66102	Sheep Creek	51°35'N, 115°29'W	Banff	132 ft. (40 m) b.t.
66108	Mt. Tyrrell	51°41'N, 115°50'W	middle Banff	374 ft. (114 m) b.t. of Banff
66112	Mt. Tyrrell	51°41'N, 115°50'W	upper Banff	207 ft. (63 m) b.t.
66113	Mt. Tyrrell	51°41'N, 115°50'W	upper Banff	183 ft. (56 m) b.t.
66115	Mt. Tyrrell	51°41'N, 115°50'W	upper Banff	147 ft. (45 m) b.t.
66117	Mt. Tyrrell	51°41'N, 115°50'W	upper Banff	106 ft. (32 m) b.t.
66119	Mt. Tyrrell	51°41'N, 115°50'W	upper Banff	5 ft. (1.5 m) b.t.
66326	Canyon Creek	50°54'30"N, 114°51'W	Banff	103 ft. (31 m) b.t.
66327	Canyon Creek	50°54'30"N, 114°51'W	Banff	100 ft. (30 m) b.t.
66329	Canyon Creek	50°54'30"N, 114°51'W	Banff	55 ft. (17 m) b.t.
66330	Canyon Creek	50°54'30"N, 114°51'W	Banff	31 ft. (9 m) b.t.
66331	Canyon Creek	50°54'30"N, 114°51'W	Banff	14 ft. (4 m) b.t.
66332	Canyon Creek	50°54'30"N, 114°51'W	Banff	0-2 ft. (0-0.6 m) b.t.
66347	Mt. Rundle	51°10'N, 115°33'W	upper Banff	123 ft. (38 m) b.t.
66348	Mt. Rundle	51°10'N, 115°33'W	upper Banff	77 ft. (23 m) b.t.
66349	Mt. Rundle	51°10'N, 115°33'W	upper Banff	48-57 ft. (14-17 m) b.t.
68445	Fagan Lake	51°36'N, 115°46'W	Banff	508-518 ft. (155-158 m) b.t.
68447	Fagan Lake	51°36'N, 115°46'W	Banff	488-492 ft. (149-150 m) b.t.
68448	Fagan Lake	51°36'N, 115°46'W	Banff	477 ft. (145 m) b.t.
68449	Fagan Lake	51°36'N, 115°46'W	Banff	458 ft. (140 m) b.t.

GSC locality	Stratigraphic section	Location	Formation	Stratigraphic position
68451	Fagan Lake	51°36'N, 115°46'W	Banff	435 ft. (133 m) b.t.
68452	Fagan Lake	51°36'N, 115°46'W	Banff	416 ft. (127 m) b.t.
68453	Fagan Lake	51°36'N, 115°46'W	Banff	384 ft. (117 m) b.t.
68455	Fagan Lake	51°36'N, 115°46'W	Banff	278 ft. (85 m) b.t.
68456	Fagan Lake	51°36'N, 115°46'W	Banff	228-233 ft. (70-71 m) b.t.
68457	Fagan Lake	51°36'N, 115°46'W	Banff	160-155 ft. (49-47 m) b.t.
68458	Fagan Lake	51°36'N, 115°46'W	Banff	140-142 ft. (43 m) b.t.
68459	Fagan Lake	51°36'N, 115°46'W	Banff	50 ft. (15 m) b.t.
68460	Fagan Lake	51°36'N, 115°46'W	Banff	0-2 ft. (0-0.6 m) b.t.
68486	Clearwater River	51°47'N, 116°19'W	Banff	250 ft. (76 m) b.t.
68487	Clearwater River	51°47'N, 116°19'W	Banff	204-229 ft. (62-70 m) b.t.
68516	Sentinel Mountain	52°05'N, 116°26'W	Banff	320-335 ft. (97-102 m) b.t.
68517	Sentinel Mountain	52°05'N, 116°26'W	Banff	320 ft. (97 m) b.t.
68518	Sentinel Mountain	52°05'N, 116°26'W	Banff	340 ft. (103 m) b.t.
68519	Sentinel Mountain	52°05'N, 116°26'W	Banff	325 ft. (99 m) b.t.
68521	Sentinel Mountain	52°05'N, 116°26'W	Banff	235-241 ft. (71-73 m) b.t.
68522	Sentinel Mountain	52°05'N, 116°26'W	Banff	200 ft. (61 m) b.t.
68523	Sentinel Mountain	52°05'N, 116°26'W	Banff	30 ft. (9 m) b.t.
68524	Sentinel Mountain	52°05'N, 116°26'W	Banff	10 ft. (3 m) b.t.
68567	Forbidden Creek	51°48'N, 115°50'W	Banff	270-283 ft. (82-86 m) b.t.
68570	Forbidden Creek	51°48'N, 115°50'W	Banff	87 ft. (26 m) b.t.
68571	Forbidden Creek	51°48'N, 115°50'W	Banff	18 ft. (5 m) b.t.
68573	Forbidden Creek	51°48'N, 115°50'W	Banff	8-9 ft. (2-3 m) b.t.
68593	Forbidden Creek	51°48'N, 115°50'W	upper Banff	uncertain
69548	Mt. Rundle	51°09'N, 115°33'W	Banff	493-503 ft. (150-153 m) b.t.
69547	Mt. Rundle	51°09'N, 115°33'W	Banff	198 ft. (60 m) b.t.
69549	Mt. Rundle	51°09'N, 115°33'W	Banff	253-263 ft. (77-80 m) b.t.
69550	Mt Rundle	51°09'N, 115°33'W	Banff	164-174 ft. (50-53 m) b.t.
69552	Mt. Rundle	51°09'N, 115°33'W	Banff	825 ft. (251 m) b.t.
69554	Mt. Rundle	51°09'N, 115°33'W	upper third of middle Banff	630-635 ft. (192-194 m) b.t. of Banff

GSC locality	Stratigraphic section	Location	Formation	Stratigraphic position
69555	Mt. Rundle	51°09'N, 115°33'W	upper third of middle Banff	approx. 600 ft. (182 m) b.t. of Banff
69556	Mt. Rundle	51°09'N, 115°33'W	Banff	324 ft. (99 m) b.t.
69557	Mt. Rundle	51°09'N, 115°33'W	Banff	140-145 ft. (43-44 m) b.t.
69558	Mt. Rundle	51°09'N, 115°33'W	Banff	138 ft. (42 m) b.t.
69559	Mt. Rundle	51°09'N, 115°33'W	Banff	47-50 ft. (14-15 m) b.t.
69560	Mt. Rundle	51°09'N, 115°33'W	Banff	8 ft. (2 m) b.t.
69562	Mt. Rundle	51°09'N, 115°33'W	middle Banff	approx. 600 ft. (182 m) b.t. of Banff (talus)
69565	Pigeon Mountain	51°01'30"N, 115°13'W	Banff	615 ft. (187 m) b.t.
69567	Pigeon Mountain	51°01'30"N, 115°33'W	Banff	375 ft. (114 m) b.t.
69568	Pigeon Mountain	51°01'30"N, 115°33'W	Banff	345-350 ft. (105-107 m) b.t.
69569	Pigeon Mountain	51°01'30"N, 115°33'W	Banff	330 ft. (100 m) b.t.
69570	Pigeon Mountain	51°01'30"N, 115°33'W	Banff	259 ft. (79 m) b.t.
69571	Pigeon Mountain	51°01'30"N, 115°33'W	Banff	238-241 ft. (72-73 m) b.t.
69572	Pigeon Mountain	51°01'30"N, 115°33'W	Banff	185-199 ft. (56-61 m) b.t.
73521	North Cascade	51°25'N, 115°45'W	Banff	529 ft. (161 m) b.t.
73526	North Cascade	51°25'N, 115°45'W	Banff	263-266 ft. (80-82 m) b.t.
73527	North Cascade	51°25'N, 115°45'W	Banff	224-226 ft. (68-69 m) b.t.
73528	North Cascade	51°25'N, 115°45'W	Banff	132 ft. (40 m) b.t.
74856	Cadomin	52°59'N, 117°20'W	Banff	230-250 ft. (70-76 m) b.t.
74858	Cadomin	52°59'N, 117°20'W	Banff	96 ft. (29 m) b.t.
74859	Cadomin	52°59'N, 117°20'W	Banff	211 ft. (64 m) b.t. (talus)
74860	Cadomin	52°59'N, 117°20'W	Banff	211 ft. (64 m) b.t.
74861	Cadomin	52°50'N, 117°20'W	Banff	81 ft. (25 m) b.t. (talus)
74862	Cadomin	52°59'N, 117°20'W	Banff	66-68 ft. (20-21 m) b.t.
74866	Nordegg	52°29'N, 116°04'W	Banff	approx. 400-500 ft. (122-152 m) b.t.
74884	Minnewanka	51°15'N, 115°28'W	Banff	309 ft. (94 m) b.t.
74886	White Man Pass	51°05'N, 115°26'W	Banff	323 ft. (98 m) b.t.
74887	White Man Pass	51°05'N, 115°26'W	Banff	316 ft. (96 m) b.t.
74893	White Man Pass	51°05'N, 115°26'W	Banff	156-158 ft. (47- 48 m) b.t.

GSC locality	Stratigraphic section	Location	Formation	Stratigraphic position
74895	White Man Pass	51°05'N, 115°26'W	Livingstone	3 ft. (1 m) a.b.
74931	Deception Creek	52°51'N, 117°21'W	Banff	189-194 ft. (57-59 m) b.t (talus)
C-4129	Mt. Greenock	53°06'N, 118°04'30"W	Banff	120 ft. (37 m) b.t.
C-4130	Mt. Greenock	53°06'N, 118°04'30"W	Banff	152 ft. (46 m) b.t.
C-4132	Tunnel Mountain	51°10'N, 115°33'W	Banff	65 ft. (20 m) b.t.
C-7382	Mt. Becker	54°32'N, 120°39'W	Banff	335-338 ft. (102-103 m) a.b.
C-7383	Mt. Becker	54°32'N, 120°39'W	Banff	390-395 ft. (119-120 m) a.b.
C-7388	Belcourt Creek	54°22'N, 120°29'30"W	Banff	69 ft. (21 m) b.t.
C-11785	Fellers Creek	54°42'30"N, 120°54'W	upper Banff	uncertain
C-11787	Fellers Creek	54°39'N, 120°59'W	upper Banff	uncertain
C-28282	Fiddle River	53°07'30"N, 117°43'W	upper Banff	uncertain
C-57468	Lake Minnewanka	51°15'N, 115°28'W	upper Banff	260 ft. (79 m) b.t.
C-57469	Jura Creek	51°05'N, 115°10'W	Banff	575 ft. (175 m) b.t.
C-57470	Grotto Mountain	51°03'N, 115°14'W	Banff	472 ft. (144 m) b.t.
C-57471	Grotto Mountain	51°03'N, 115°14'W	Banff	467 ft. (142 m) b.t.
C-57474	South of Evan Thomas Creek	50°52'N, 115°10'W	upper Banff	6.5 ft. (2 m) a.b. of upper Banff
C-86542	Canyon Creek	50°54'N, 114°53'W	Banff	75 ft. (23 m) b.t.
C-86543	Canyon Creek	50°54'N, 114°53'W	Banff	15 ft. (5 m) b.t.
C-86544	Canyon Creek	50°54'N, 114°53'W	Banff	21 ft. (6 m) b.t.
C-86545	Southwest side of hill north of Morro Peak	53°03'N, 118°04'W	upper Banff	uncertain (top bed of ridge-forming unit)
C-86546	Mt. Rundle	51°09'N, 115°33'W	Banff	uncertain

APPENDIX 2

Range charts for brachiopod species

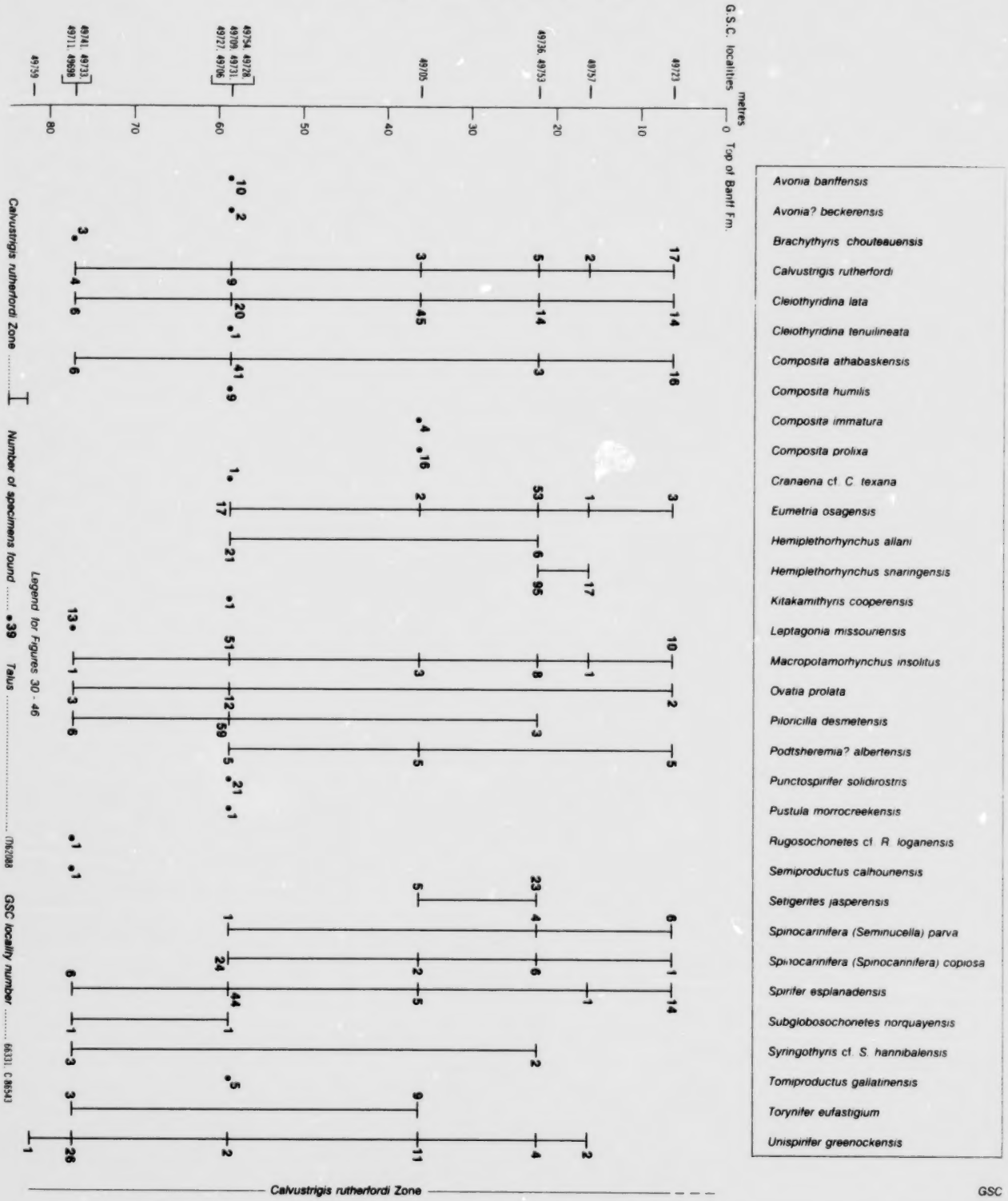


Figure 30. *Brachiopod distribution, Mt. Greenock Section (locality 5) (R.A.C. Brown, 1952, p. 33, Sections IB and IC, Thrust Block I).*

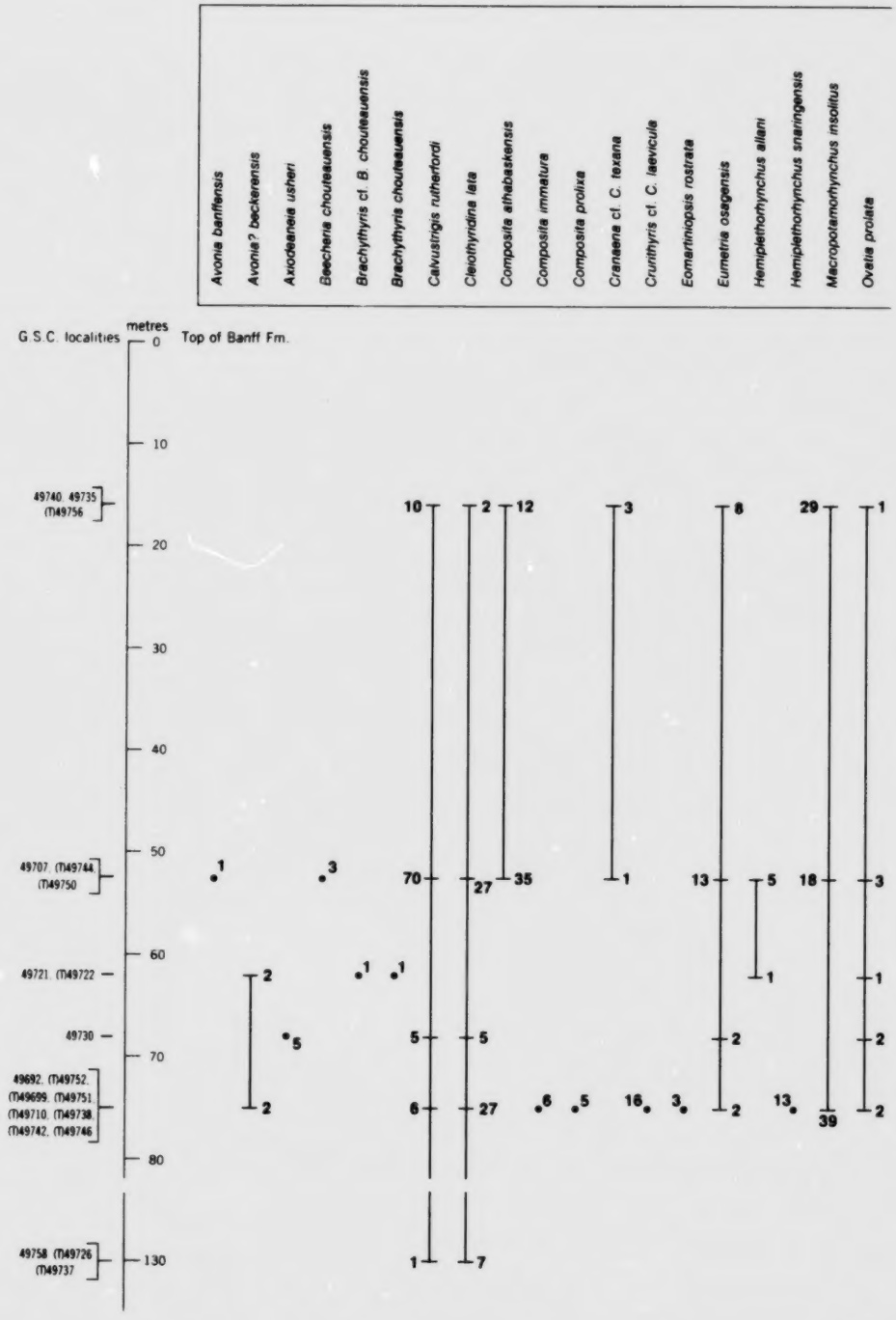
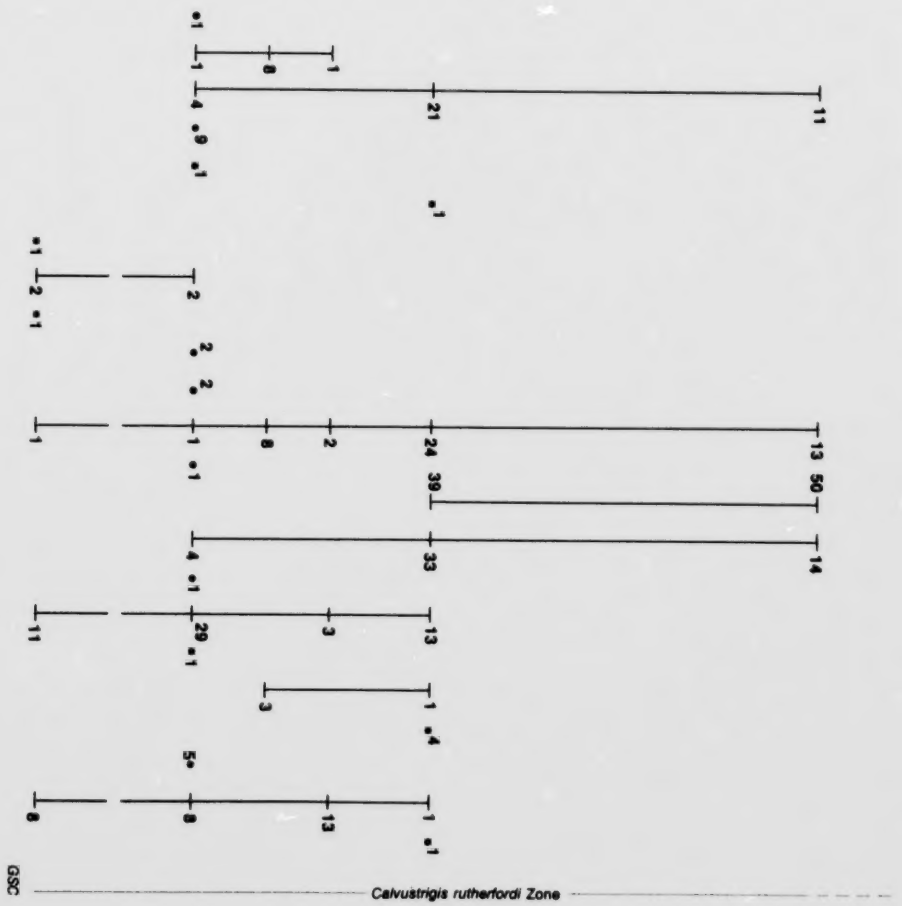


Figure 31. *Brachiopod distribution, Cobblestone Creek (locality 6) (R.A.C. Brown, 1952, p. 49, Section IIID, Thrust Block III).*



Overtonioid gen. et. sp. indet. B

Piloricilla desmetensis

Podtsheremia? albertensis

Prospira cf. *P. albapinensis*

Pseudopentagonia cf. *P. injensis*

Pustula morrocreekensis

Rhipidomella sp.

Rugosochonetes cf. *R. loganensis*

Schellwienella cf. *S. alternata*

Schellwienella cf. *S. bushbergensis*

Schizophoria cf. *S. poststriatula*

Setigerites jasperensis

Shumardella pygmaea

Spinocarinifera (Seminucella) parva

Spinocarinifera (Spinocarinifera) copiosa

Spirifer cascadensis

Spirifer esplanadensis

Streptorhynchus sp.

Syringothyris cf. *S. hannibalensis*

Tomiproductus gallatinensis

Torynifer eufastigium

Unispirifer greenockensis

Unispirifer minnewankensis

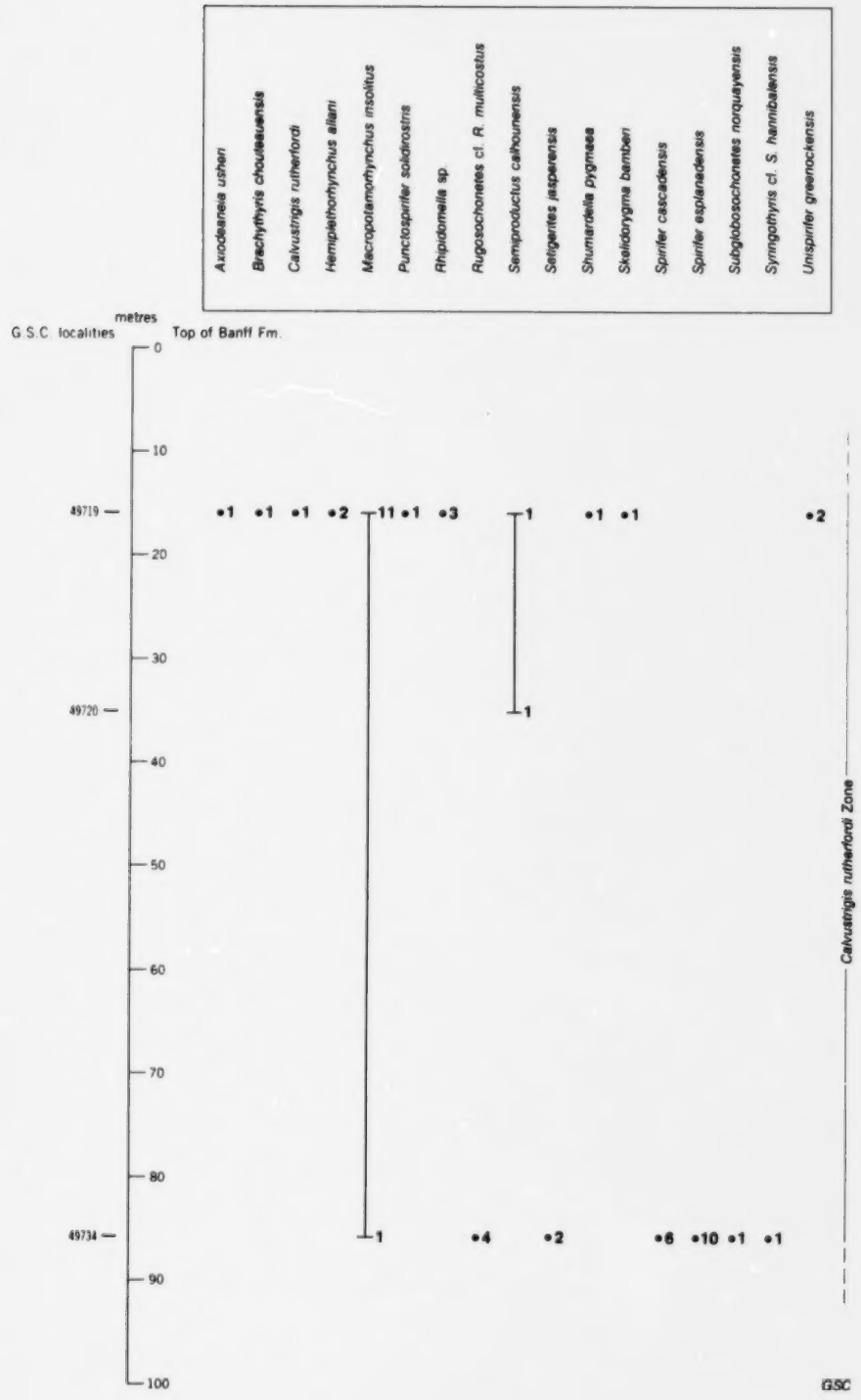


Figure 32. *Brachiopod distribution, Grassy Ridge Section (locality 7) (R.A.C. Brown, 1952, p. 38, Grassy Ridge Section IIA, Thrust Block II).*

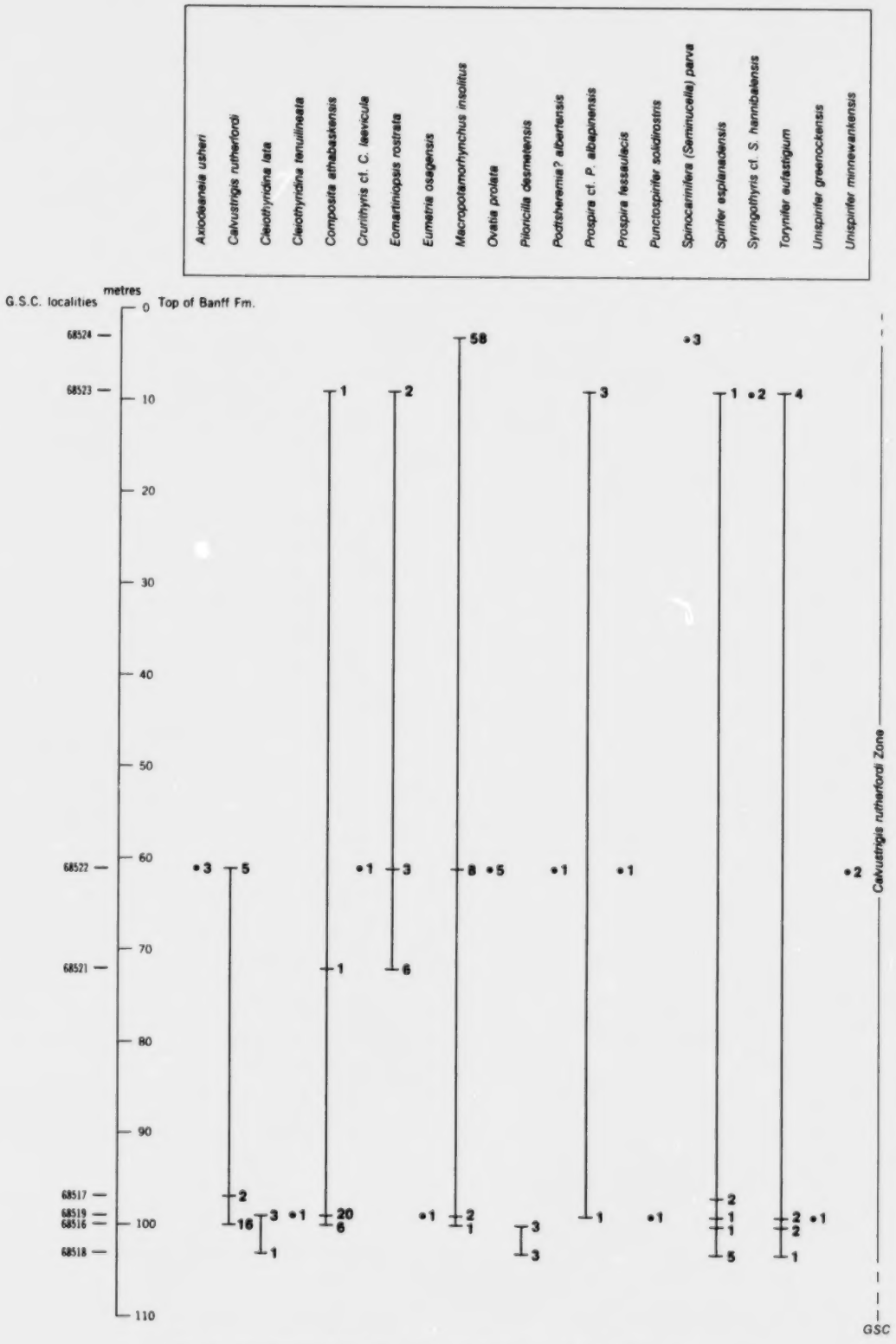


Figure 33. *Brachiopod distribution, Sentinel Mountain Section (locality 8).*

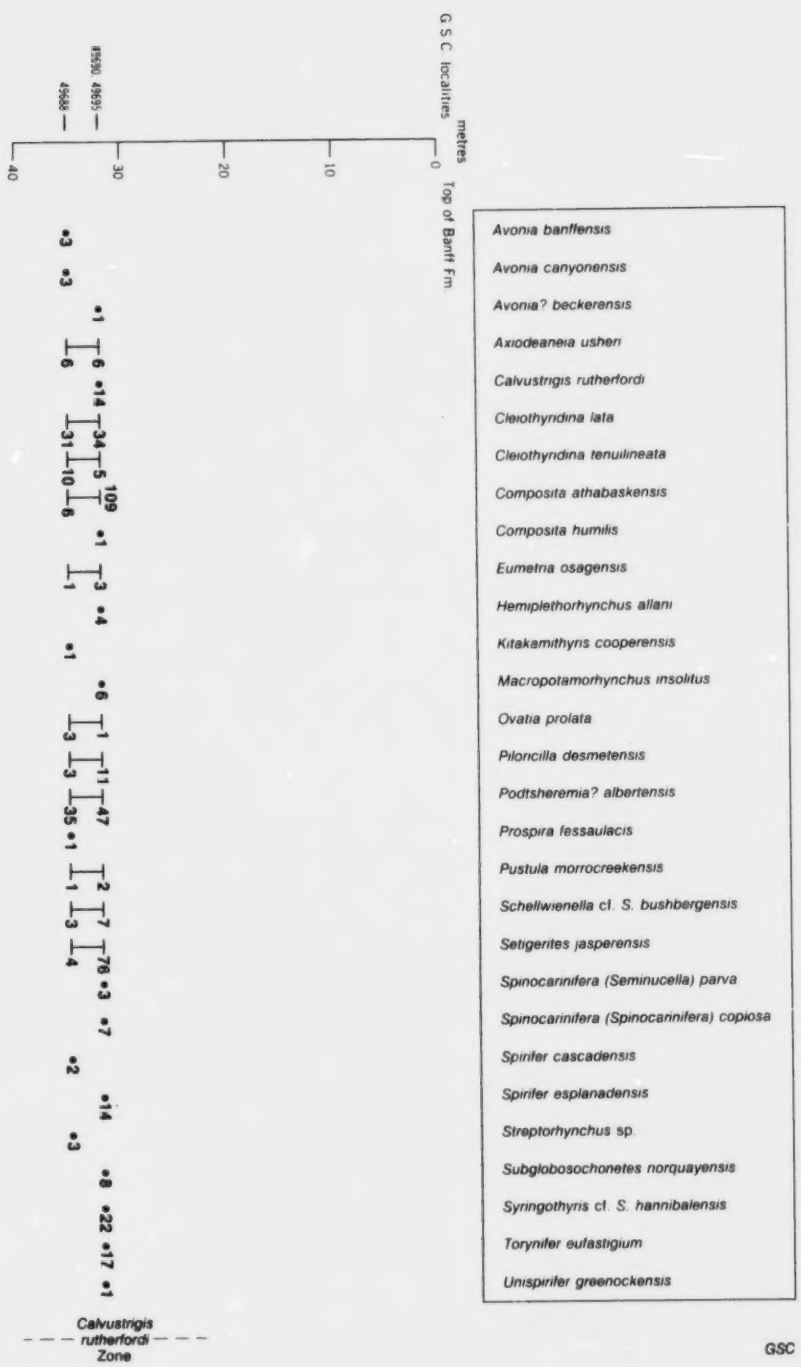


Figure 34. *Brachiopod distribution, Morro Creek Section (locality 9) (R.A.C. Brown, 1952, p. 45, Section IIIA).*

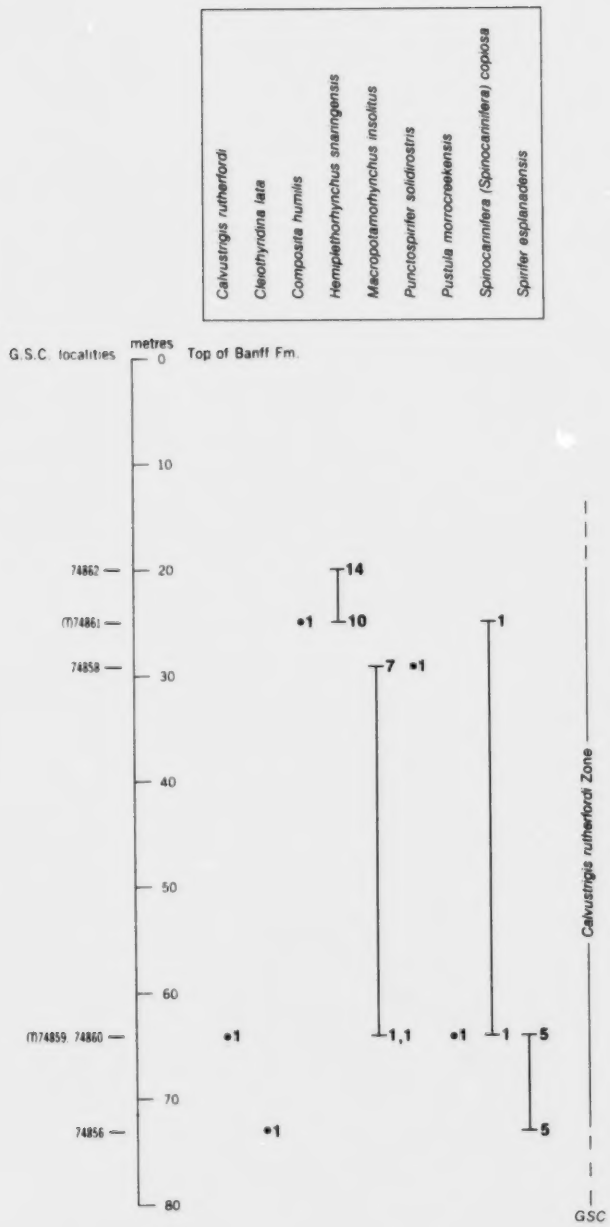


Figure 35. *Brachiopod distribution, Cadomin Section (locality 12).*

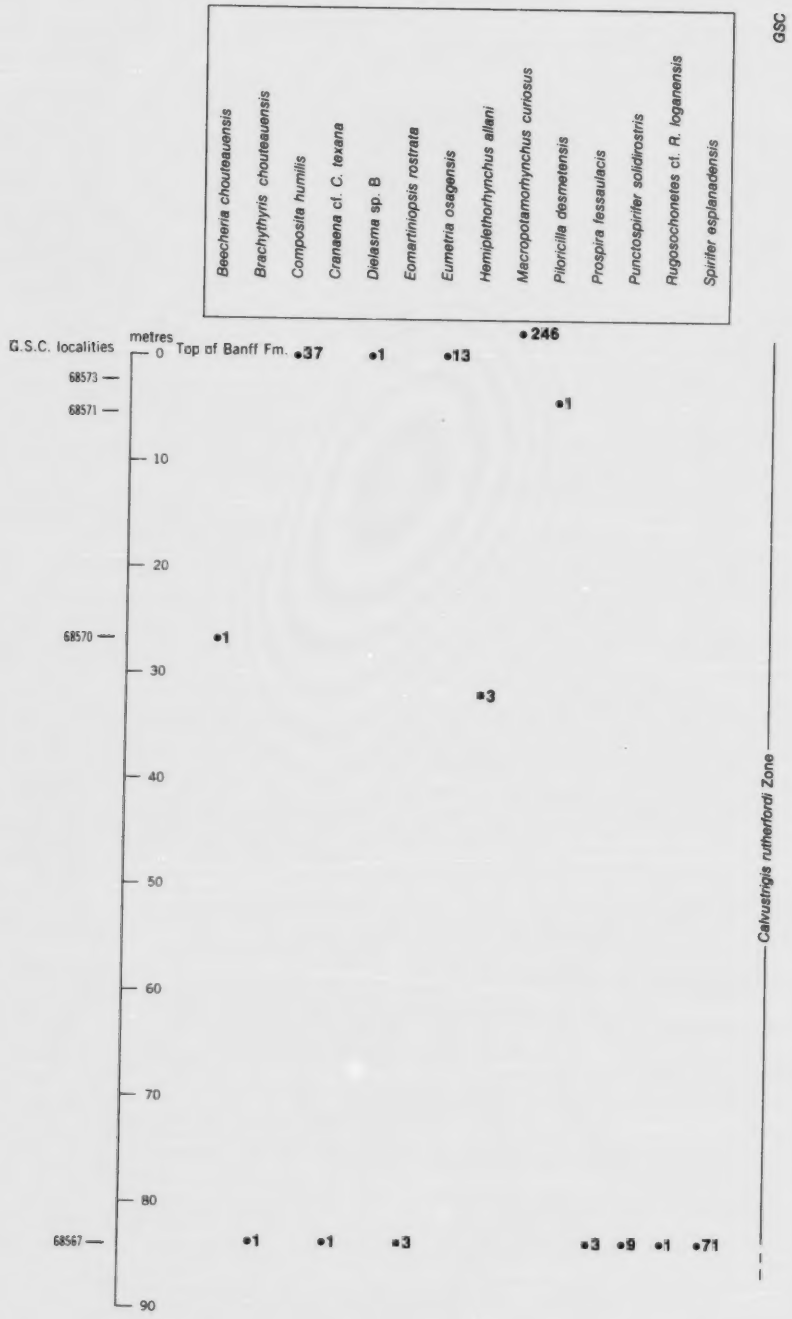


Figure 36. *Brachiopod distribution, Forbidden Creek Section (locality 19).*

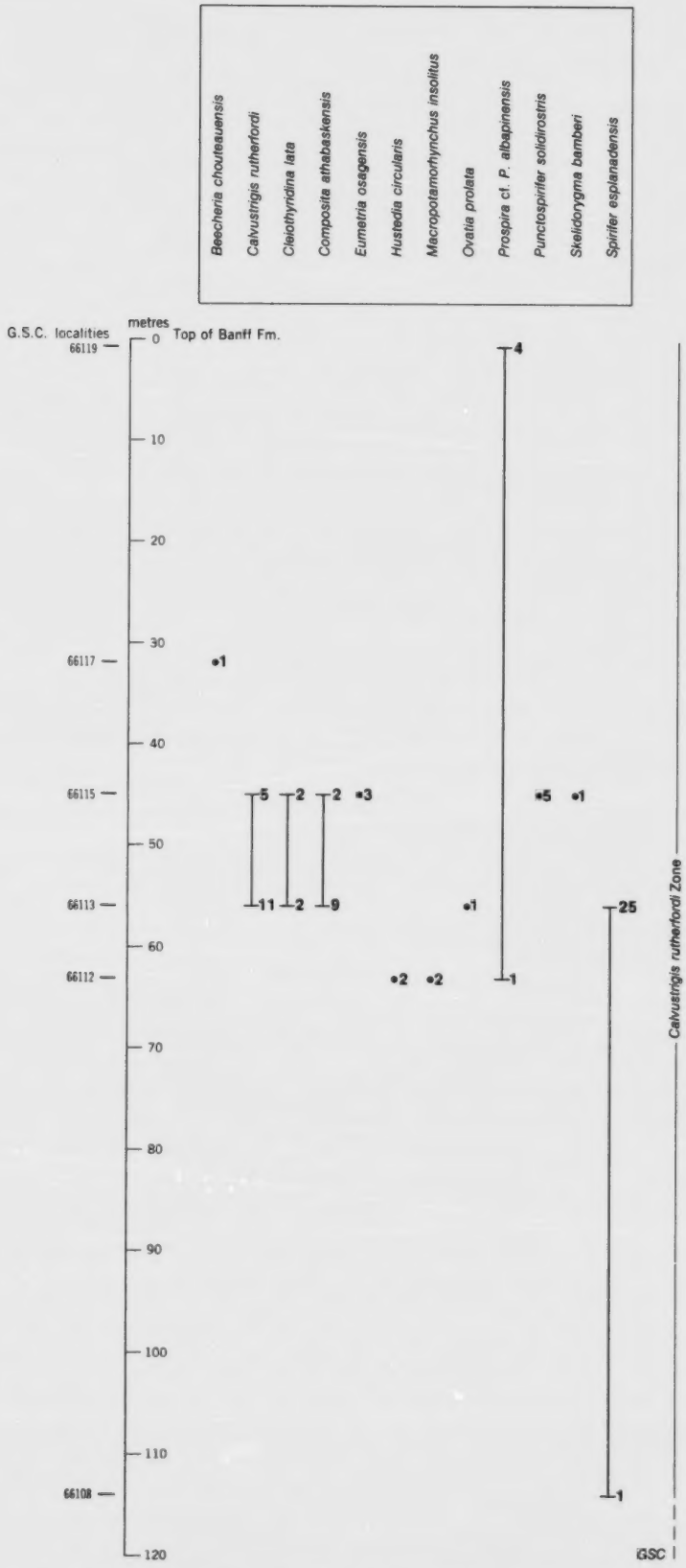


Figure 37. *Brachiopod distribution, Mt. Tyrrell Section (locality 20).*

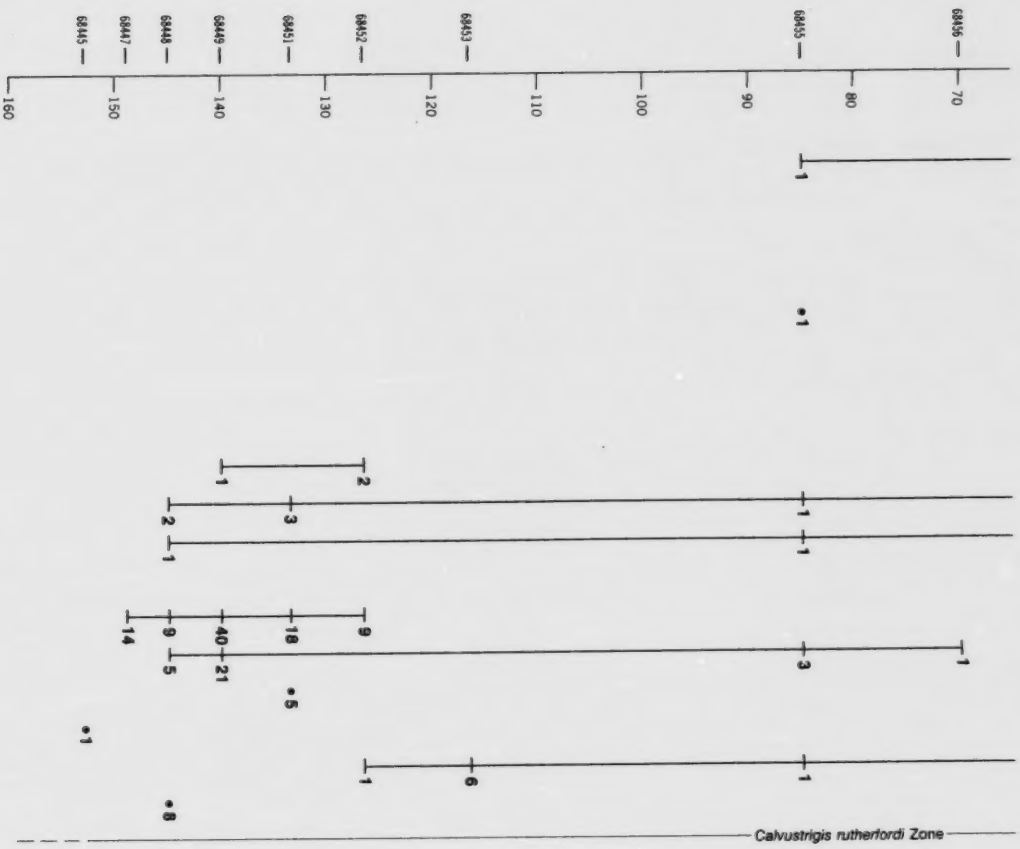
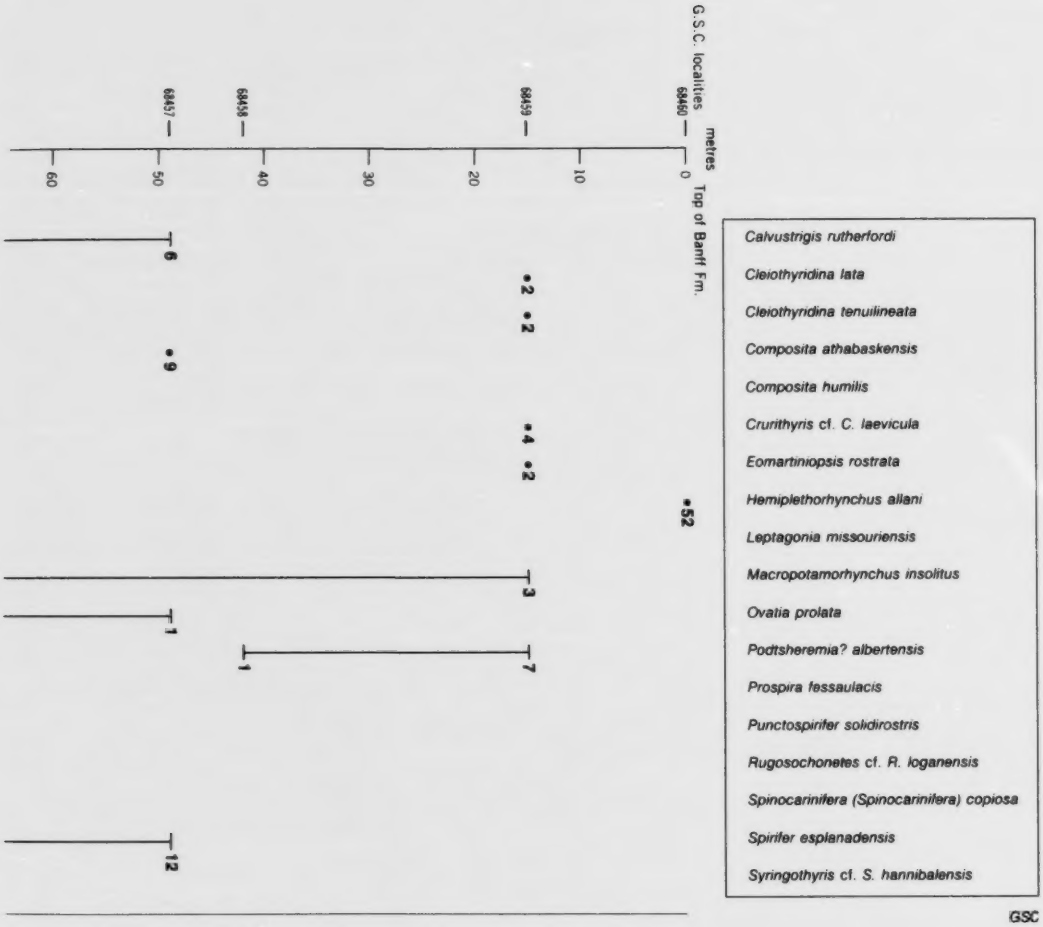


Figure 38. *Brachiopod distribution, Fagan Lake Section (locality 21).*



Calvustrigis rutherfordi

Cleiothyridina lata

Cleiothyridina tenuilineata

Composita athabaskensis

Composita humilis

Crurithyris cf. *C. laevicula*

Eomartiniopsis rostrata

Hemiplethorhynchus allani

Leptagonia missouriensis

Macropotamorhynchus insolitus

Ovatia prolata

Podtsheremia? albertensis

Prospira fessaulacis

Punctospirifer solidirostris

Rugosochonetes cf. *R. loganensis*

Spinocarinifera (Spinocarinifera) copiosa

Spirifer esplanadensis

Syringothyris cf. *S. hannibalensis*

GSC

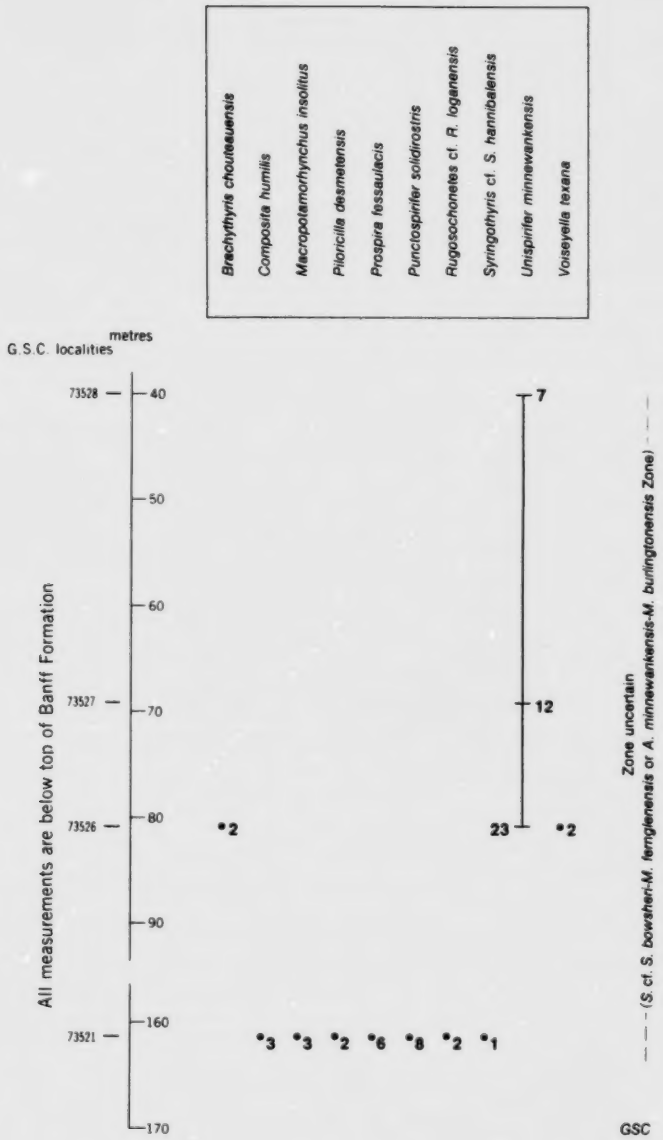


Figure 39. *Brachiopod distribution, North Cascade Section (locality 22).*

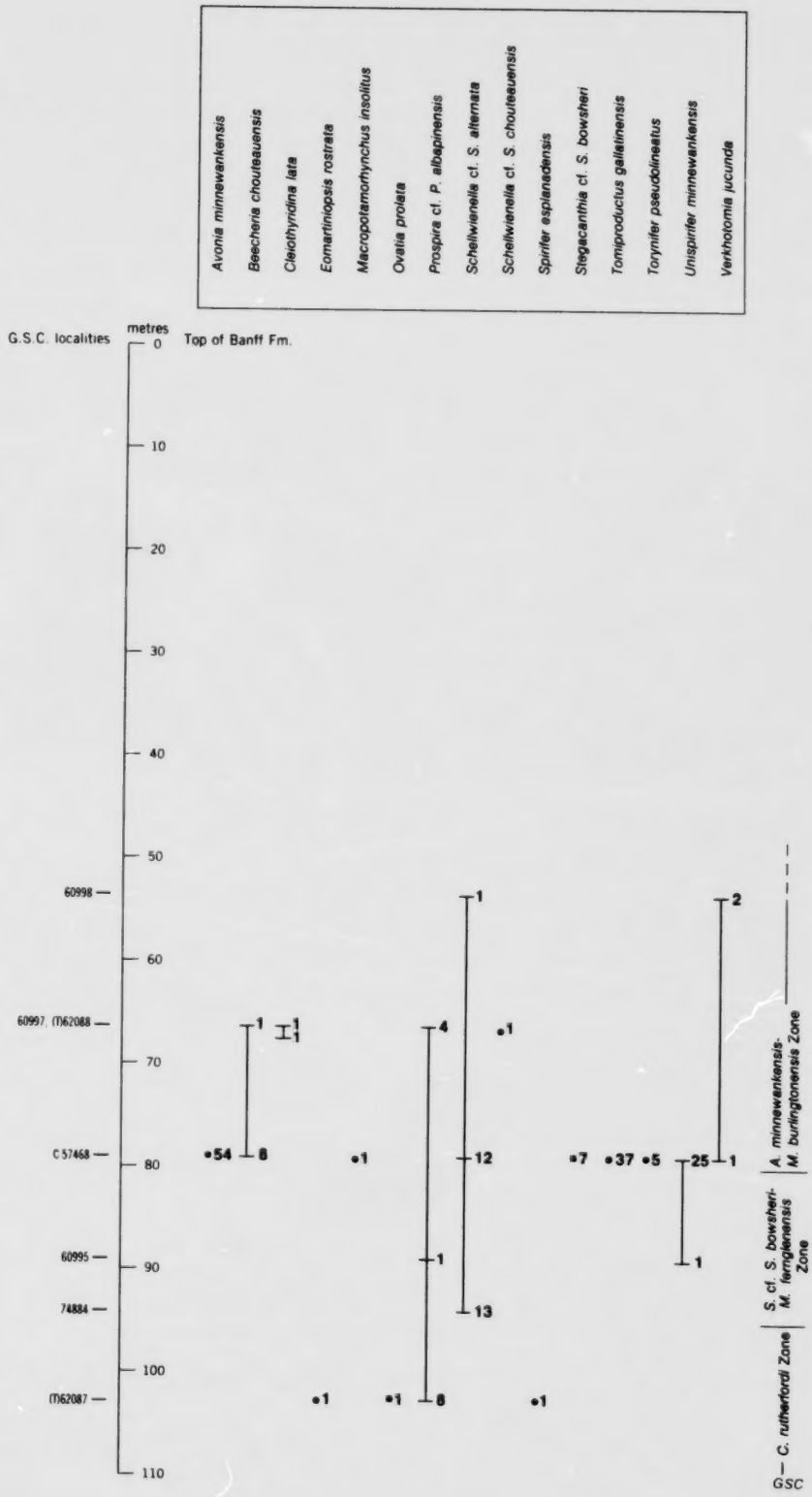


Figure 40. *Brachiopod distribution, Lake Minnewanka Section (locality 23).*

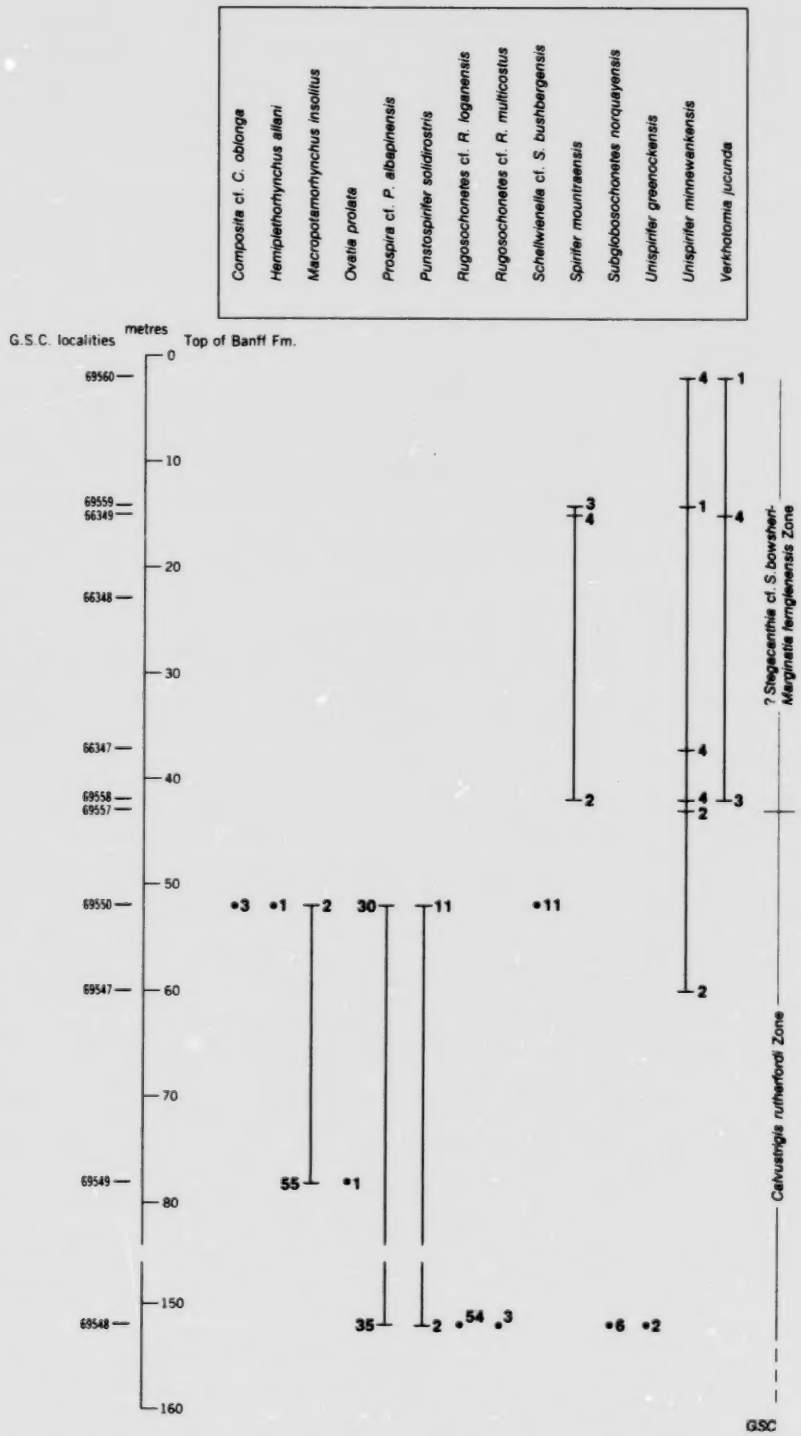


Figure 41. *Brachiopod distribution, Mt. Rundle (locality 26).*

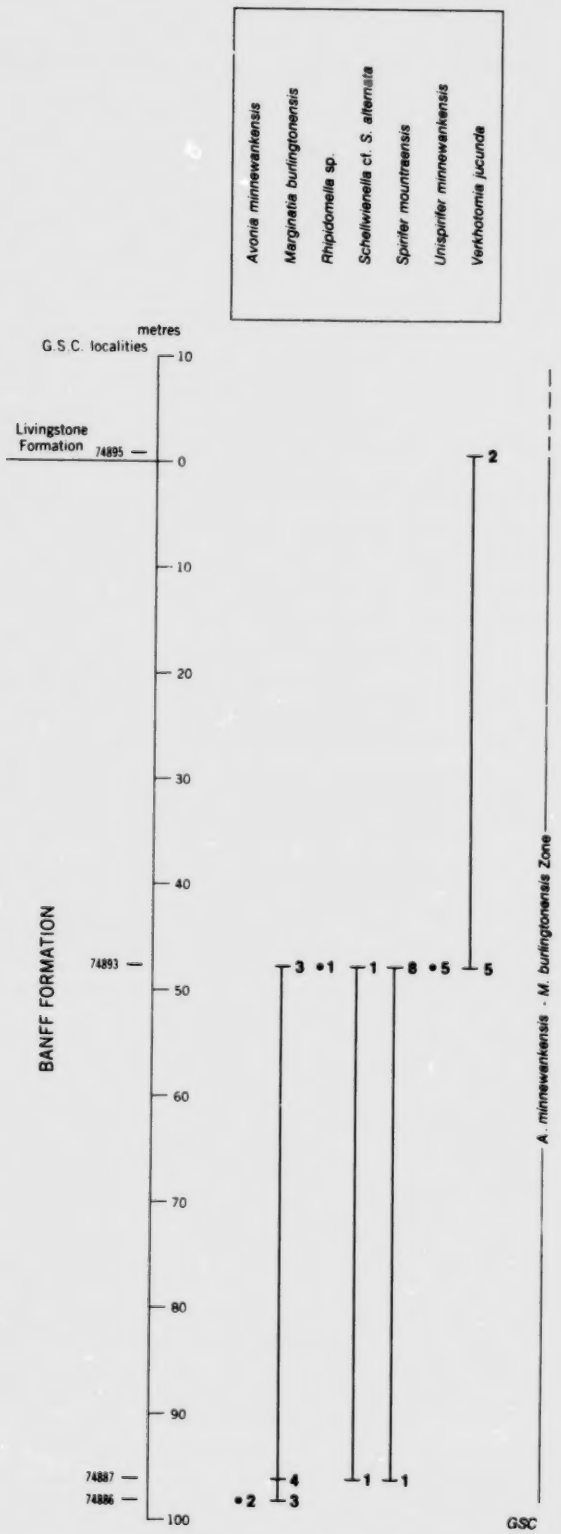


Figure 42. *Brachiopod distribution, White Man Pass Section (locality 27).*

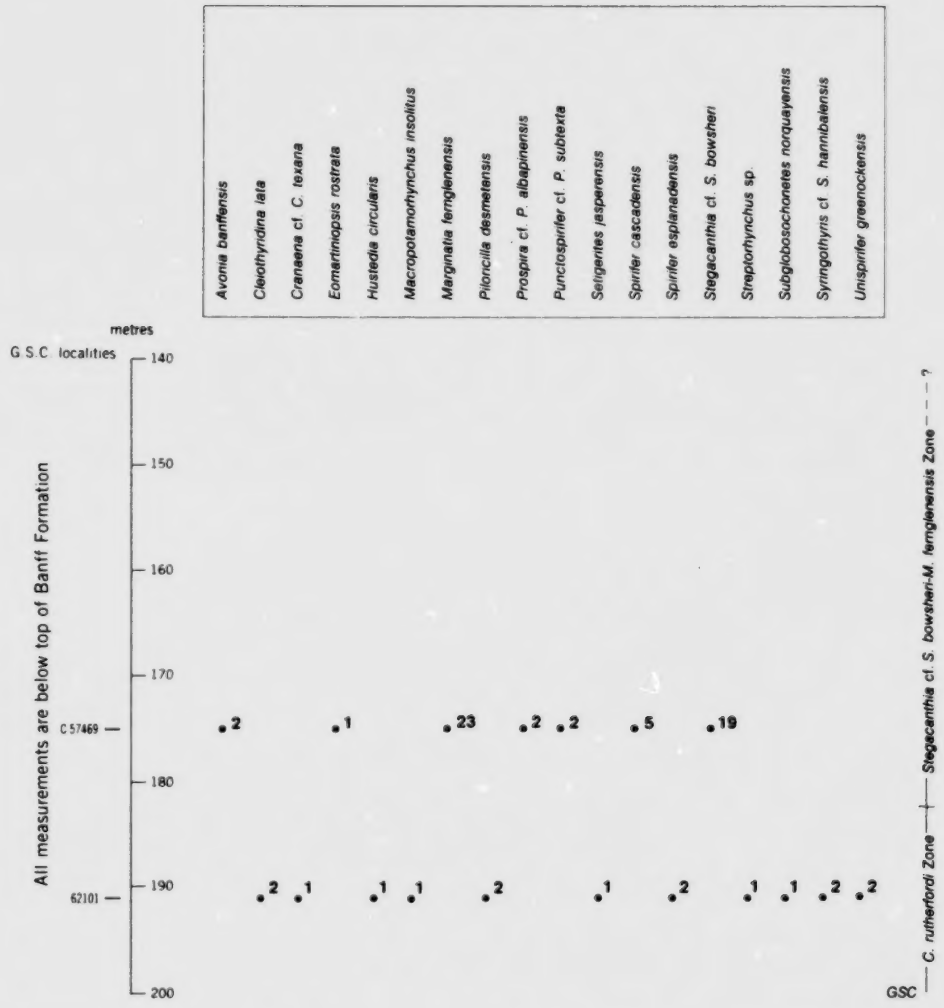


Figure 43. *Brachiopod distribution, Jura Creek Section (locality 28).*

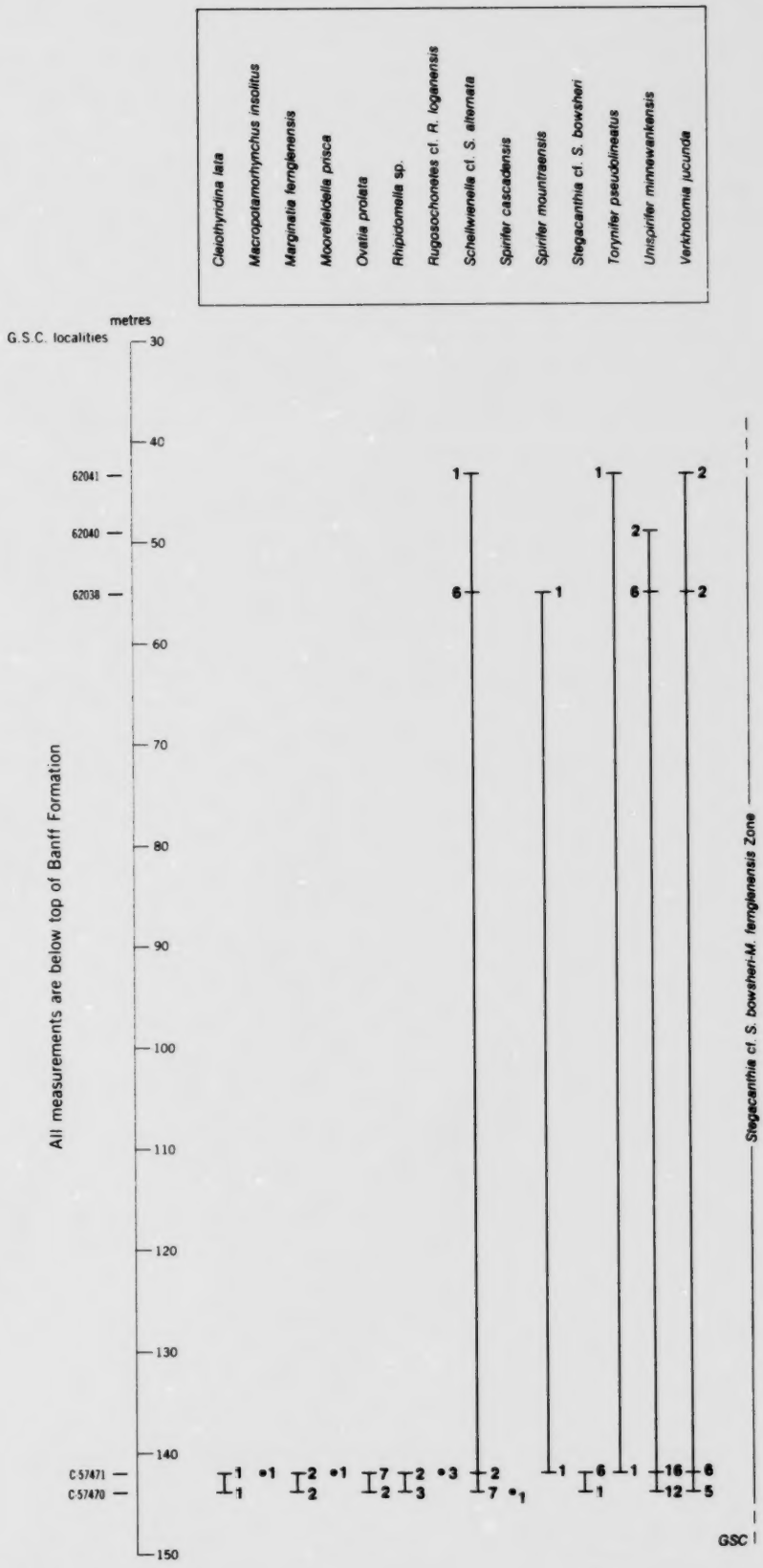


Figure 44. *Brachiopod distribution, Grotto Mountain Section (locality 29).*

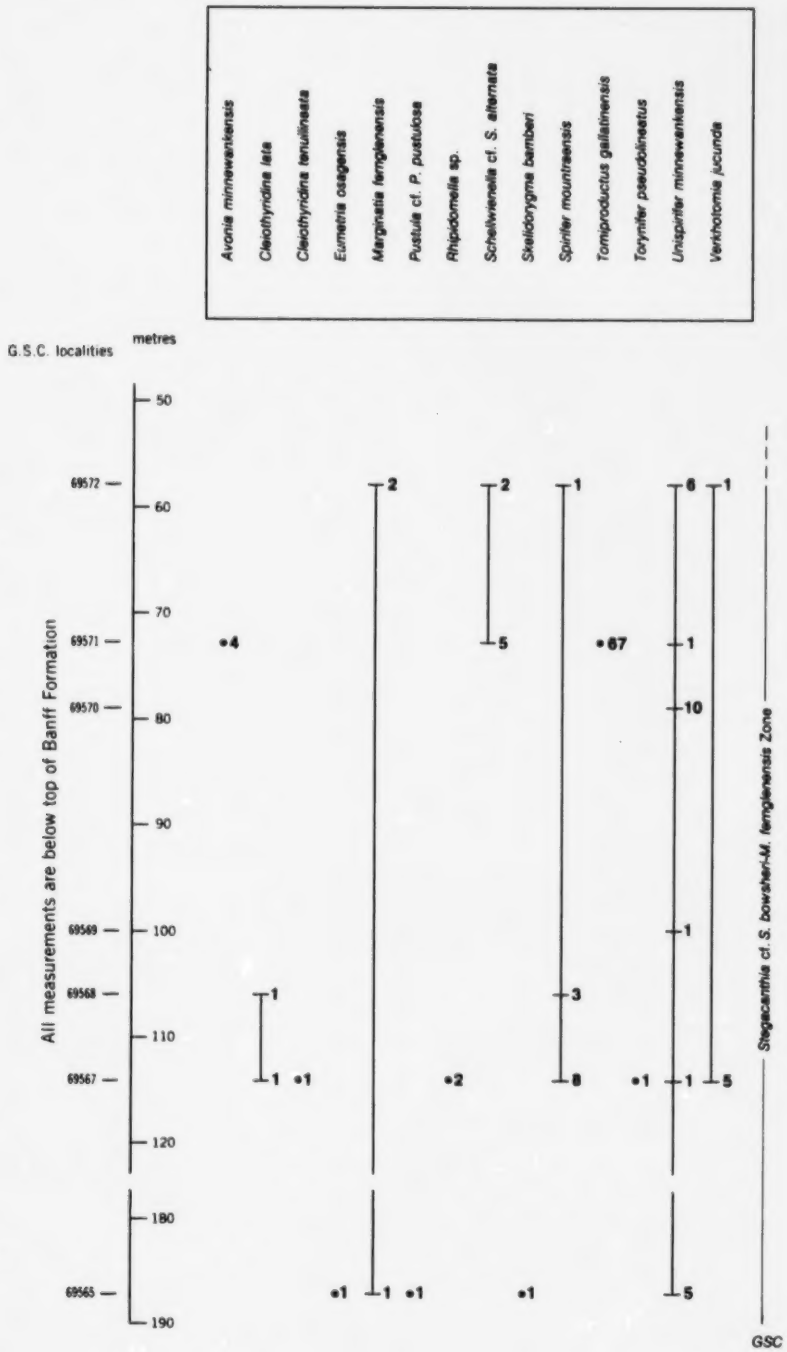


Figure 45. *Brachiopod distribution, Pigeon Mountain Section (locality 30).*

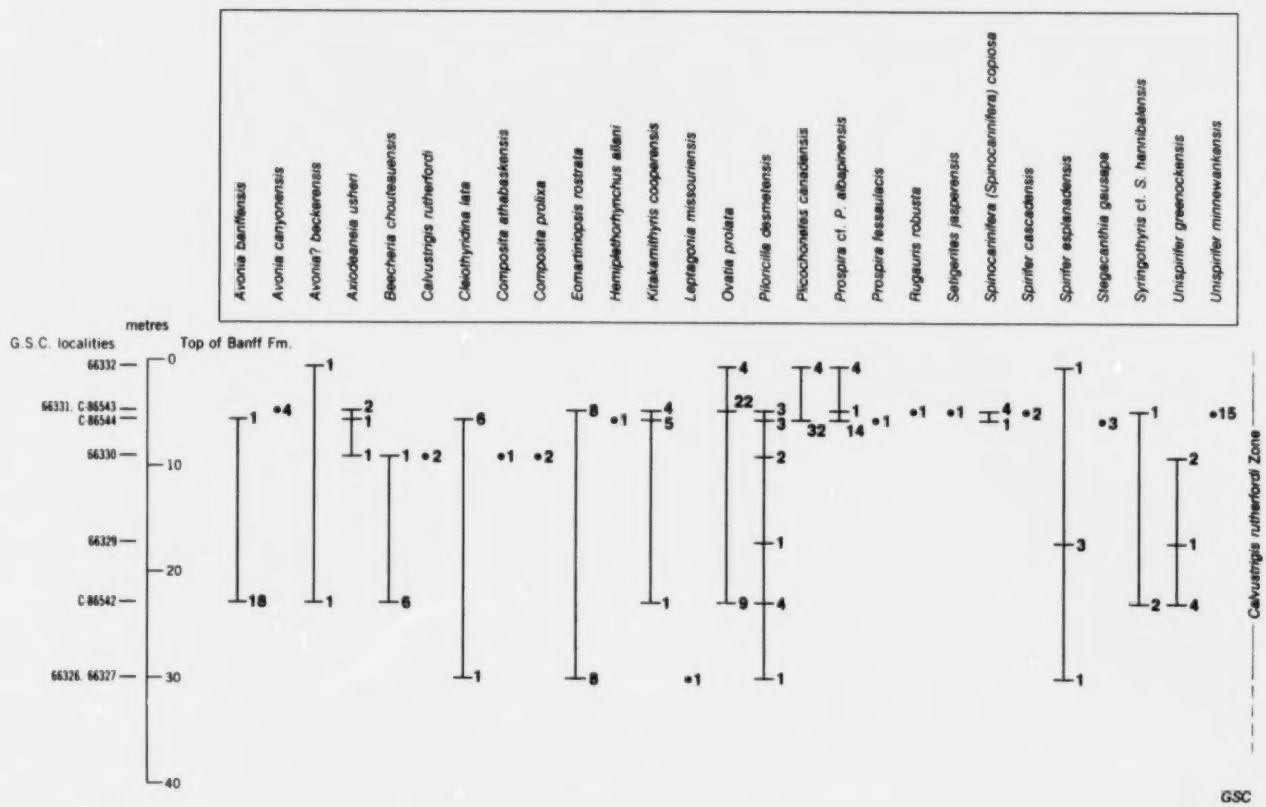


Figure 46. *Brachiopod distribution, Canyon Creek Section (locality 32).*

PLATE 1

Figures 1, 2. *Lingula* sp. (Page 20)

1. GSC 58647, GSC locality 31367; x3.
2. GSC 63184, GSC locality 18852; x3.

Figures 3, 4. *Orbiculoidea* sp. (Page 20)

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4. Pedicle valve, GSC 63186, GSC locality 31367; x3.

Figure 5. *Rhipidomella* sp. (Page 21)

Pedicle valve, GSC 63187, GSC locality 69567; x2.

Figures 6-10. *Schizophoria* cf. *S. poststriatula* Weller (Page 20)

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Figures 11-15. *Leptagonia missouriensis* Carter (Page 21)

11-14. Ventral, anterior, posterior, and lateral views, GSC 63188, GSC locality 74866; x1.

15. Brachial valve interior, GSC 10060a, GSC locality 18550; x1.

Figure 16. *Streptorhynchus* sp. (Page 23)

Pedicle valve, GSC 63189, GSC locality 49690; x1.

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18. Brachial valve, GSC 63191, GSC locality 49704; x1.
19. Brachial valve, GSC 63192, GSC locality 49726; x1.

Figures 20-25. *Schellwienella* cf. *S. chouteauensis* Weller (Page 22)

20, 21, 25. Ventral, posterior, and dorsal views, GSC 10079a, GSC locality 18293; x1.

22-24. Ventral, dorsal, and lateral views, GSC 10079b, GSC locality 18293; x1.

Figures 26, 27. *Schellwienella*? cf. *S. alternata* Weller (Page 21)

26. Pedicle valve, GSC 10061a, GSC locality 18527; x1.
27. Brachial valve, GSC 10061b, GSC locality 18527; x1.

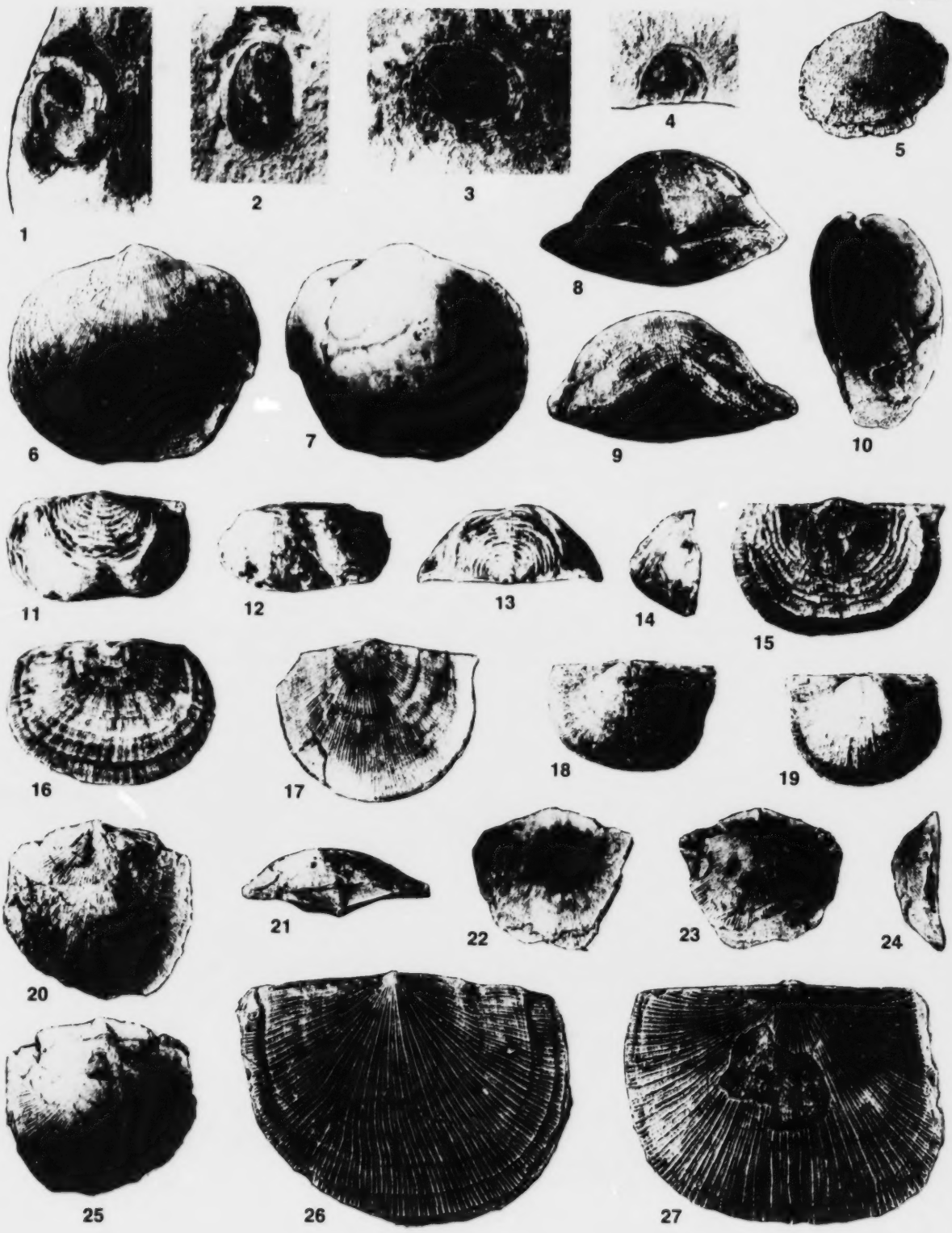
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PLATE 2

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	13-15.	Ventral, dorsal, and posterior views, GSC 63194, GSC locality 37131; x2.	
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	20, 24.	Latex casts of natural moulds of two brachial valve exteriors, paratypes GSC 63201 and 63202.	
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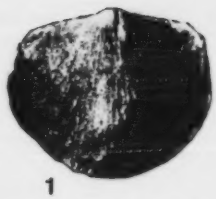
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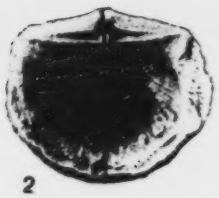
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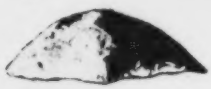
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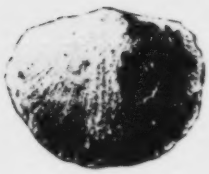
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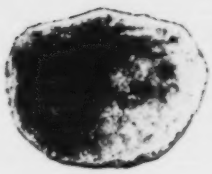
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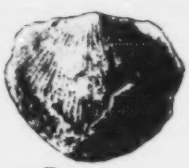
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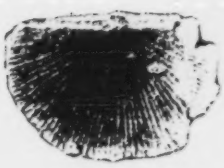
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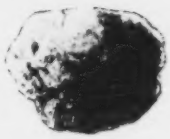
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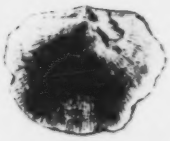
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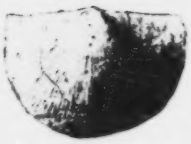
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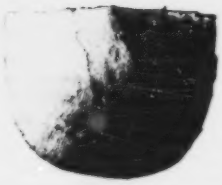
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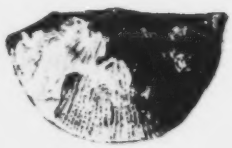
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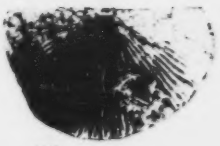
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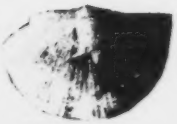
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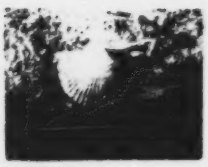
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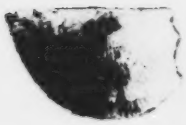
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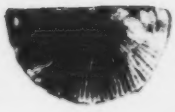
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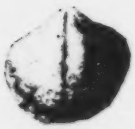
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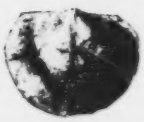
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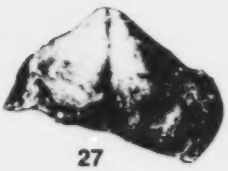
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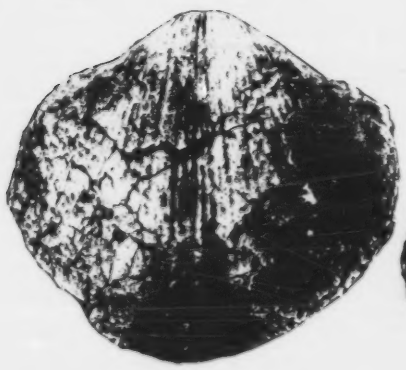
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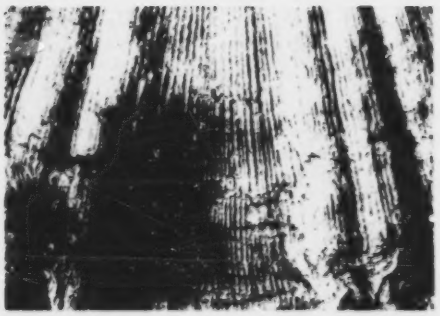
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PLATE 3

Figures 1-20. *Spinocarinifera* (*Seminucella*) *parva* n. sp. (Page 27)

1-4. Ventral, anterior, posterior, and lateral views of the holotype, GSC 63207, GSC locality 49707; x3.

5-8. Ventral, anterior, posterior, and lateral views of paratype, GSC 63208, GSC locality 49707; x3.

9-12. Ventral, anterior, posterior, and lateral views of paratype GSC 63209, GSC locality 49707; x3.

13-16. Ventral, anterior, posterior, and lateral views of paratype GSC 63210, GSC locality 49707; x3.

17, 18. Two natural moulds of brachial valve exteriors, paratypes GSC 63211 and 63212, GSC locality 49707; x3.

19. Natural mould of a brachial valve interior with part of the cardinalia preserved, paratype GSC 63213, GSC locality 49707; x3.

20. Brachial valve interior, paratype GSC 63214, GSC locality 49707; x3.

Figures 21-32. *Avonia*? *beckerensis* n. sp. (Page 32)

21-24. Ventral, anterior, posterior, and lateral views of the holotype, GSC 63238, GSC locality C-7382; x1.5.

25-28. Ventral, anterior, posterior, and lateral views of a small paratype, GSC 63239, GSC locality C-4130; x1.5.

29-32. Ventral, anterior, posterior, and lateral views of a very small paratype, GSC 63240, GSC locality C-86542; x3.

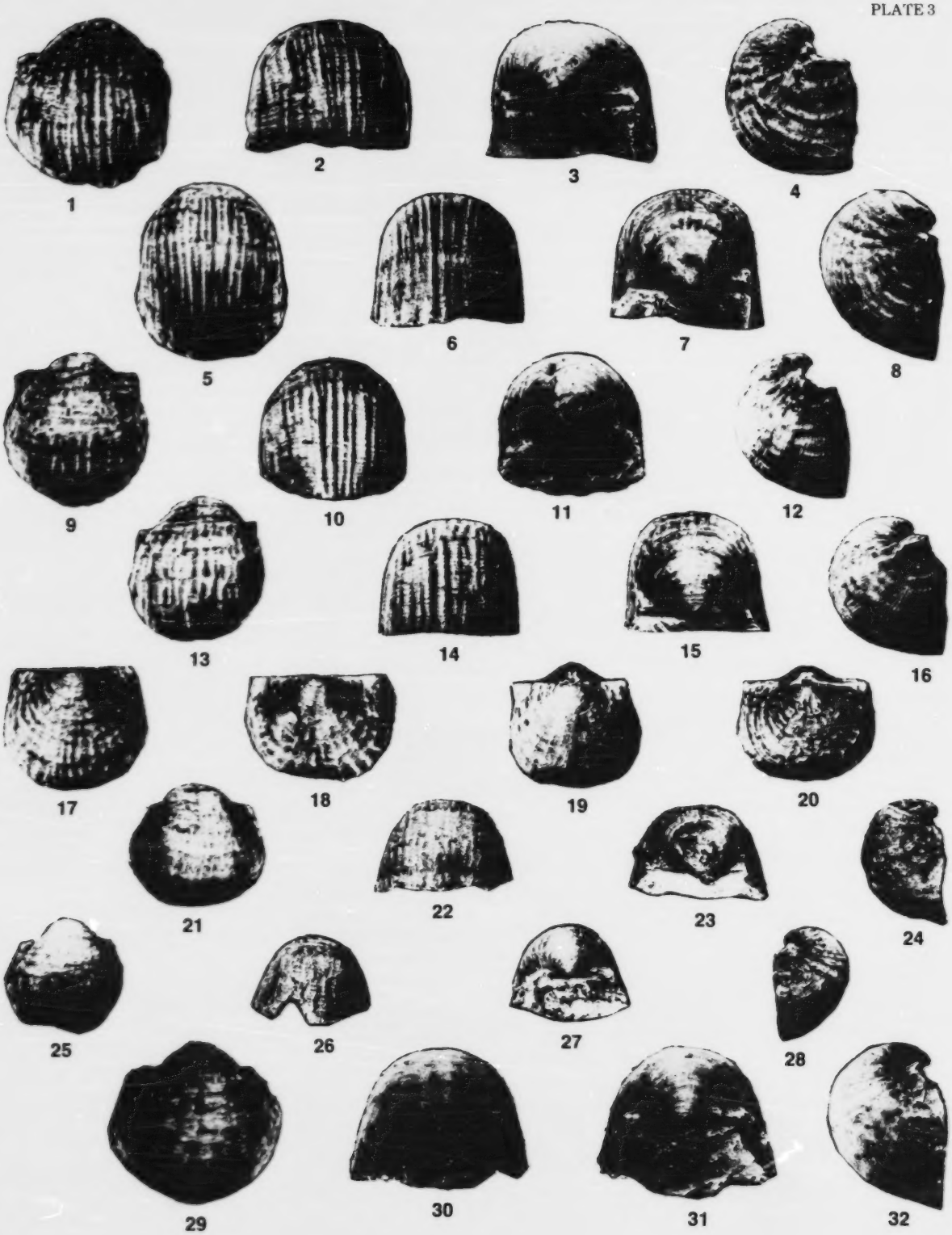
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PLATE 4

Figures 1-26. *Spinocarinifera* (*Spinocarinifera*) *copiosa* n. sp. (Page 27)

1-4. Ventral, anterior, posterior, and lateral views of large paratype, GSC 63215, GSC locality 49692; x1.5.

5-8. Ventral, anterior, posterior, and lateral views of the silicified holotype, GSC 63216, GSC locality C-7388; x1.5.

9-12. Ventral, anterior, posterior, and lateral views of paratype, GSC 63217, GSC locality C-4129; x1.5.

13-16. Ventral, anterior, posterior, and lateral views of silicified paratype, GSC 63218, GSC locality C-7388, x1.5.

17-20. Ventral, anterior, posterior, and lateral views of elongate paratype with rounded venter, GSC 63219, GSC locality 49707; x1.5.

21-25. Ventral, anterior, posterior, lateral, and dorsal views of complete silicified paratype, GSC 63220, GSC locality C-7388; x1.5.

26. Natural mould of brachial valve exterior, paratype GSC 63221, GSC locality 49707; x1.5.

Figures 27-45. *Tomiproductus gallatinensis* (Girty) (Page 38)

27, 28. Ventral and dorsal views of a natural mould of a brachial valve exterior, GSC 63271, GSC locality 59140; x1.

29-32. Ventral, anterior, posterior, and lateral views of GSC 10080e, GSC locality 18527; x1.

33-36. Ventral, anterior, posterior, and lateral views of GSC 10080d, GSC locality 18527; x1.

37-40. Ventral, anterior, posterior, and lateral views of GSC 10080, GSC locality 18527; x1.

41-45. Ventral, dorsal, anterior, posterior, and lateral views of a nearly complete shell, GSC 63272, GSC locality 59140; x1.

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PLATE 5

Figures 1-17. *Ovatia prolata* n. sp. (Page 40)

1-5, 10. Ventral, anterior, posterior, lateral and dorsal views, and a natural mould of the brachial valve exterior of a longitudinally distorted, complete paratype, GSC 63279, GSC locality C-86542; x1.

6-9. Ventral, anterior, posterior, and lateral views of an undistorted paratype, GSC 63280, GSC locality C-86542; x1.

11, 12, 16, 17. Ventral, posterior, and lateral views of the holotype, GSC 63281, GSC locality C-86543; x1.

13-15. Ventral, posterior, and lateral views of a large paratype, GSC 63282, GSC locality C-86543; x1.

Figures 18-34. *Rugauris robusta* n. sp. (Page 29)

18. Brachial valve interior, paratype GSC 63227, GSC locality C-86543; x1.5.

19. Brachial valve interior, paratype GSC 63228, GSC locality 68487; x1.5.

20-24. Ventral, dorsal, anterior, posterior, and lateral views of the holotype, GSC 63224, GSC locality 36777; x1.

25-29. Ventral, dorsal, anterior, posterior, and lateral views of paratype, GSC 63225, GSC locality 36777; x1.

30-34. Ventral, dorsal, anterior, posterior, and lateral views of paratype, GSC 63225, GSC locality 36777; x1.

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PLATE 6

Figures 1-14. *Avonia minnewankensis* (Shimer) (Page 31)

1-4. Ventral, anterior, posterior, and lateral views of the holotype, GSC 4551; x3.

5-8. Lateral, ventral, anterior, and posterior views of the paratype, GSC 4551a; x3.

9, 10. Ventral and anterior views, natural mould of a brachial valve exterior, GSC 63237, GSC locality 69571; x3.

11-14. Ventral, anterior, posterior, and lateral views of a large pedicle valve, GSC 63236, GSC locality 69571; x3.

Figures 15-18. *Avonia* sp. (Page 32)

Ventral, anterior, posterior, and lateral views, GSC 10074a, GSC locality 18293; x1.5.

Figures 19-24. *Avonia canyonensis* n. sp. (Page 30)

19-22. Ventral, anterior, posterior, and lateral views of the holotype, GSC 63234, GSC locality C-86543; x3.

23, 24. Ventral and lateral views of the paratype, GSC 63235, GSC locality C-86543; x3.

Figures 25-33. *Avonia banffensis* n. sp. (Page 30)

25-28. Ventral, anterior, posterior, and lateral views of a small paratype, GSC 63230, GSC locality C-4130; x3.

29-33. Ventral, dorsal, anterior, posterior, and lateral views of the holotype, GSC 63231, GSC locality C-86542; x3.

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PLATE 7

Figures 1-10. *Spinocarinifera* (*Seminucella*) *pustulifera* (Moore) (Page 27)

1-8. Ventral, anterior, posterior, and lateral views of two pedicle valves, Carnegie Museum, Pittsburgh, U.S.A., 34021 and 34022, respectively; x3.

9, 10. Two brachial valve interiors, each showing tiny, bilobate cardinal process with alveolus, Carnegie Museum, Pittsburgh, U.S.A., 34023 and 34024; x3.

All specimens are from the lower Burlington "white chert" (*Cryptoblastus* Zone), City Quarry, Louisiana, Pike County, Missouri, U.S.A.

Figures 11-21. *Avonia linospinosa* Sutton (Page 32)

11-13. Three brachial valve interiors, Carnegie Museum, Pittsburgh, U.S.A., 34025, 34026, and 34027, respectively; x3.

14-21. Ventral, anterior, posterior, and lateral views of two pedicle valves, Carnegie Museum, Pittsburgh, U.S.A., 34028 and 34029, respectively; x3.

All specimens are from the lower Burlington "white chert" (*Cryptoblastus* Zone), City Quarry, Louisiana, Pike County, Missouri, U.S.A.

Figures 22-26. *Productacean* gen. et sp. indet. (Page 40)

Ventral, dorsal, posterior, anterior, and lateral views, GSC 63283, GSC locality 16288; x1.5.

Figures 27-30. Overtoniid gen. et sp. indet. B (Page 36)

Ventral, anterior, posterior, and lateral views, GSC 63255, GSC locality 49692; x1.5.

Figures 31, 36. *Tomiproductus gallatinensis* (Girty) (Page 38)

31. Brachial valve interior, GSC 63273, GSC locality 69571; x2.

36. Brachial valve interior, GSC 63274, GSC locality 62111; x2.

Figures 32-35. Overtoniid gen. et sp. indet. A (Page 35)

Ventral, anterior, posterior, and lateral views, GSC 63254, GSC locality C-11787; x1.

Figures 37-43. *Avonia banffensis* n. sp. (Page 30)

37-40. Ventral, anterior, posterior, and lateral views, paratype GSC 63232, GSC locality C-4130; x3.

41-43. Ventral, anterior, and lateral views of a natural mould of a brachial valve exterior, GSC 63233, GSC locality C-86542; x3.

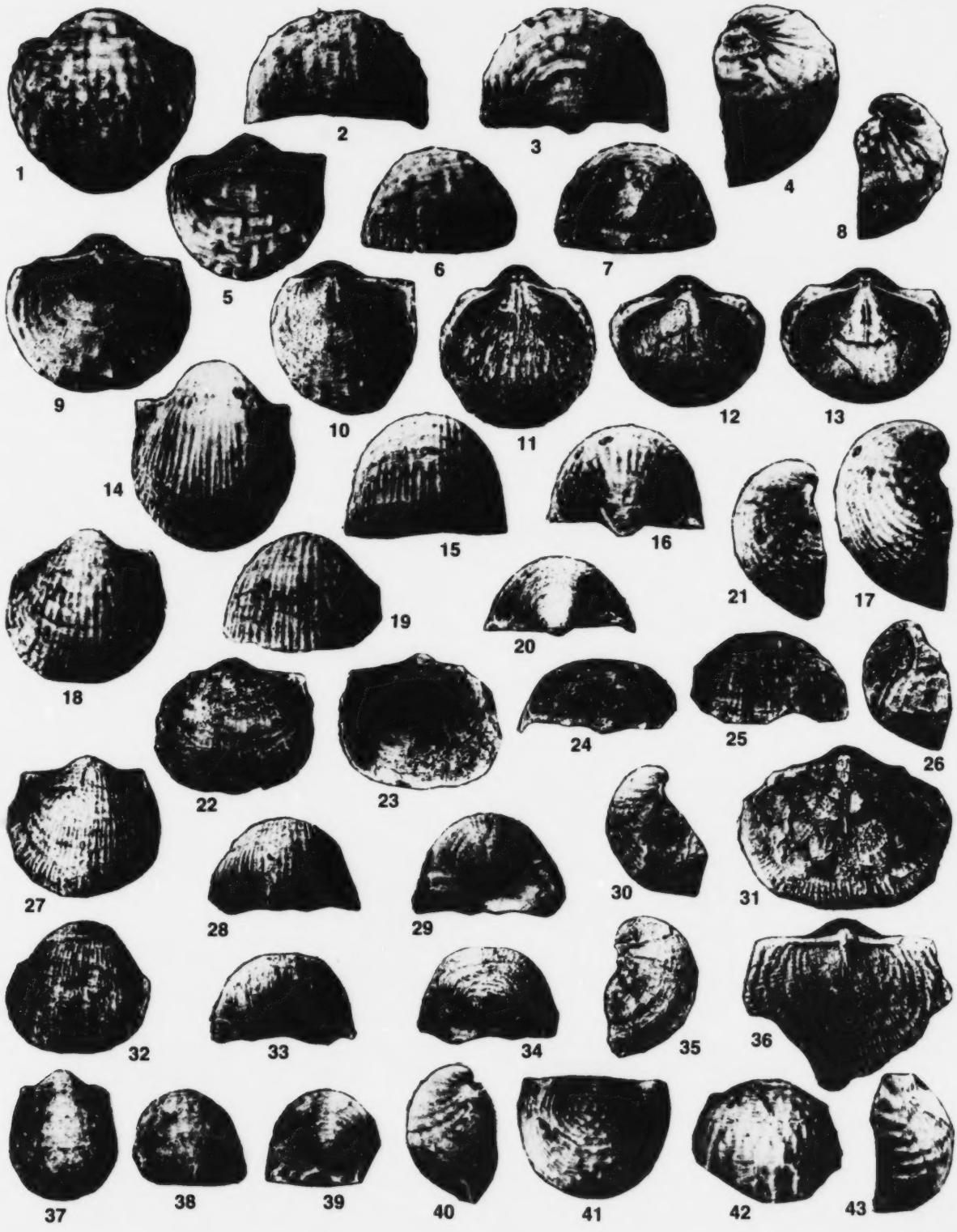
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PLATE 8

Figures 1-9. *Stegacanthia gausapa* n. sp. (Page 33)

1-4. Ventral, anterior, lateral, and posterior views of the holotype, GSC 63241, GSC locality C-86544; x1.

5-8. Ventral, anterior, lateral, and posterior views of paratype, GSC 63242, GSC locality C-86544; x1.

9. Natural mould of a brachial valve exterior, showing dorsal tip of trilobed cardinal process, paratype, GSC 63243, GSC locality C-86544; x1.

Figures 10-19. *Pustula* cf. *P. pustulosa* (Phillips) (Page 37)

10, 11. Ventral and anterior views of a small pedicle valve, GSC 63265; x1.

12-15. Ventral, anterior, lateral, and posterior views of pedicle valve, GSC 63266; x1.

16-19. Ventral, anterior, lateral, and posterior views of pedicle valve, GSC 63266; x1.

All from GSC locality 18550.

Figures 20-23. *Semiproductus calhounensis* (Moore) (Page 29)

Ventral, anterior, lateral, and posterior views of a nearly complete specimen, GSC 63229, GSC locality 49719; x1.

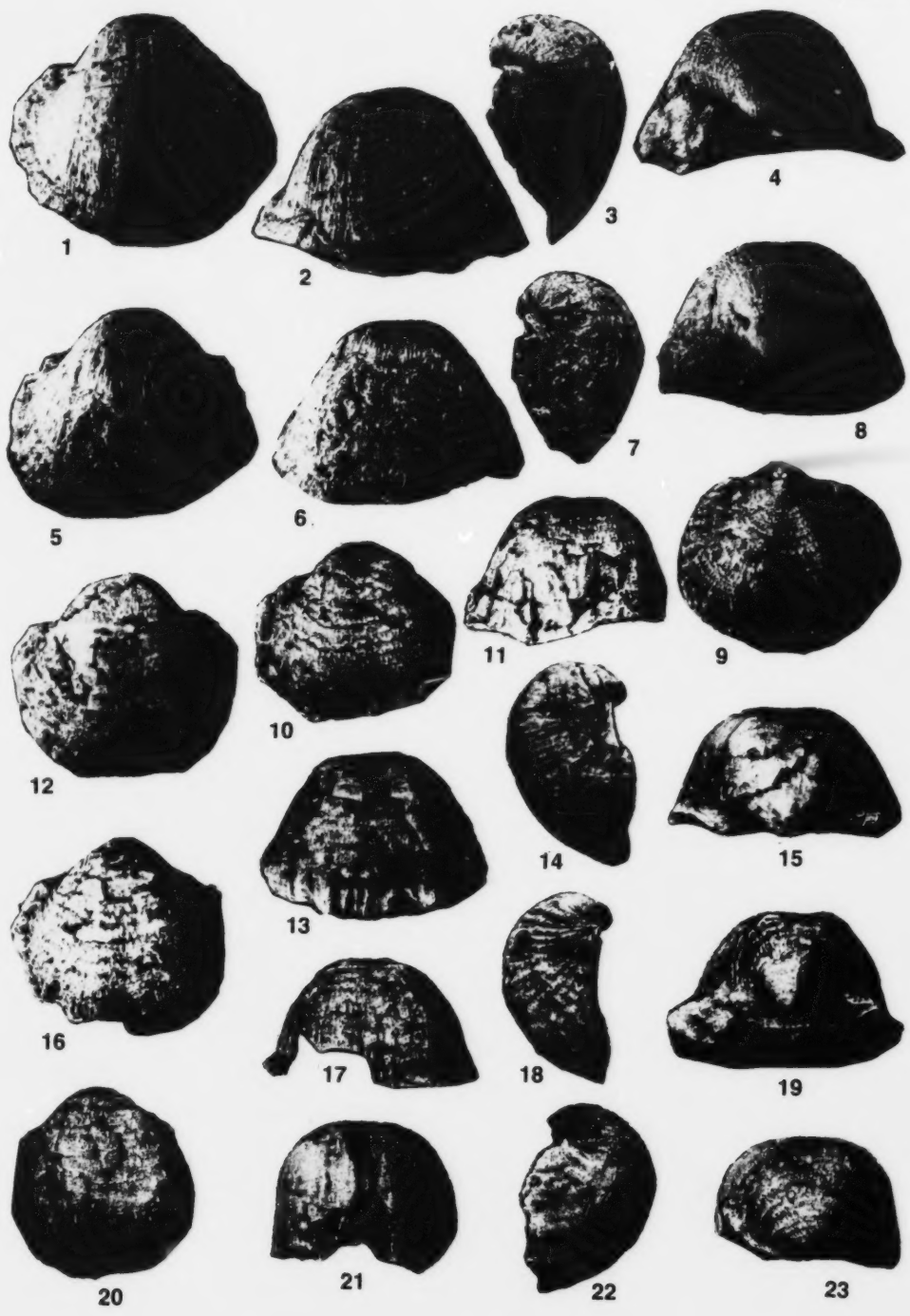
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PLATE 9

Figures 1-8. *Marginatia burlingtonensis* (Hall) (Page 39)

1-4. Ventral, anterior, lateral, and posterior views of a pedicle valve, spalled posteriorly showing ventral muscle field, GSC 63277, GSC locality 74893; x1.

5-8. Ventral, anterior, lateral, and posterior views of a silicified pedicle valve, GSC 63278, GSC locality 74893; x1.

Figures 9-35. *Piloricilla desmetensis* n. gen. n. sp. (Page 34)

9-13, 18. Ventral, anterior, lateral, posterior and dorsal views, and a natural mould of the brachial valve exterior of the holotype, GSC 63246, GSC locality 49706.

14-17. Ventral, anterior, lateral, and posterior views of large pedicle valve, paratype, GSC 63247, GSC locality 49706; x1.

19-22. Ventral, anterior, lateral, and posterior views of large pedicle valve, paratype, GSC 63247, GSC locality C-7388; x1.

23-28. Natural mould of a brachial valve exterior, and posterior, dorsal, ventral, anterior, and lateral views of a small, nearly complete specimen, paratype, GSC 63249, GSC locality C-4130; x1.

29, 30, 35. Ventral, anterior, and lateral views of a natural mould of a brachial valve exterior, paratype, GSC 63251, GSC locality C-4130; x1.

31-34. Ventral, anterior, lateral, and posterior views of a very small pedicle valve, paratype, GSC 63250, GSC locality C-4130; x1.

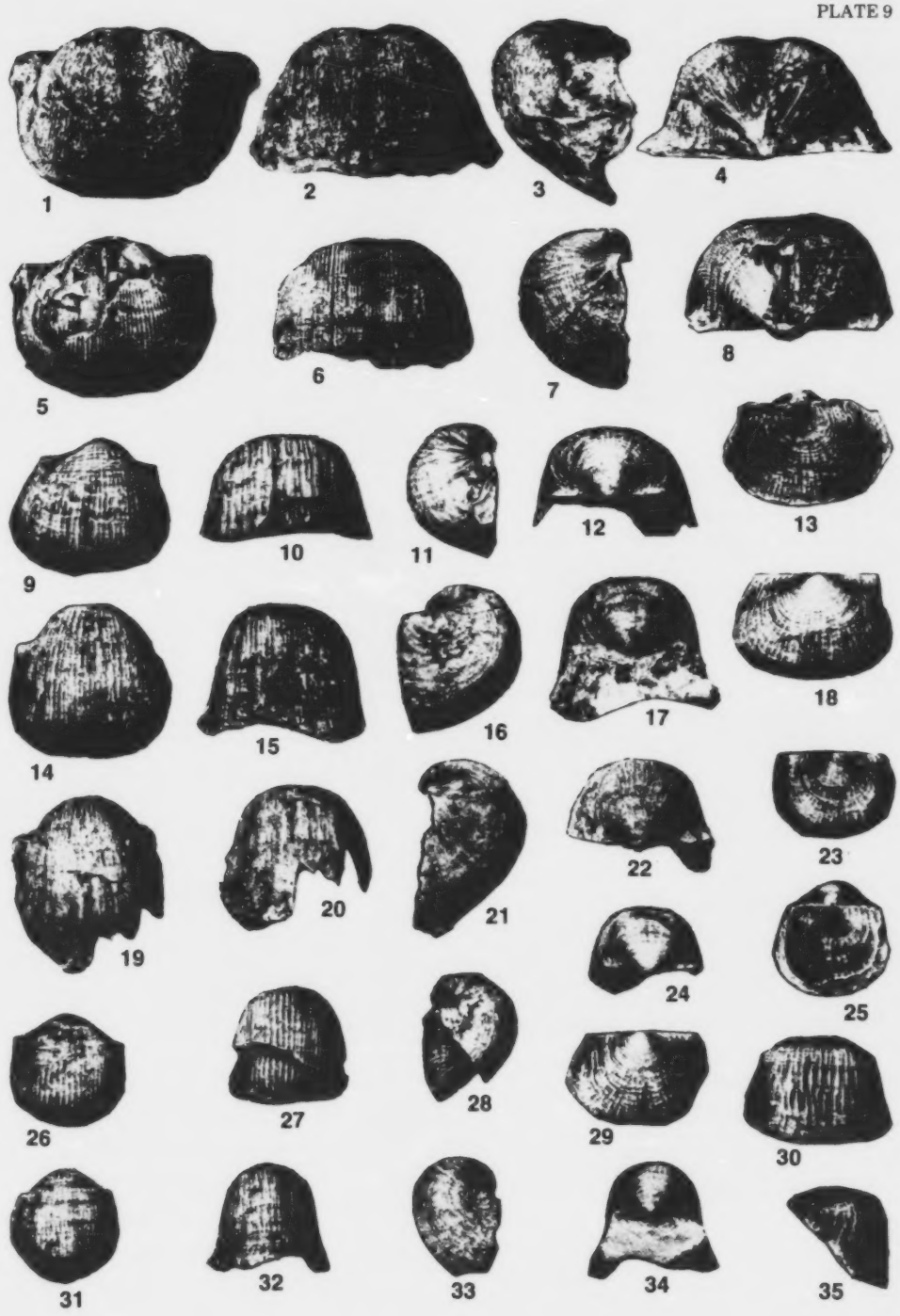
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PLATE 10

Figures 1-28. *Setigerites jasperensis* (Warren) (Page 36)

1-4. Ventral, anterior, posterior, and lateral views of large pedicle valves, GSC 63256, GSC locality 49707; x1.

5-8. Ventral, anterior, posterior, and lateral views of large pedicle valve, GSC 63257, GSC locality 49695; x1.

9-12. Ventral, anterior, posterior, and lateral views of large pedicle valve, GSC 63258, GSC locality 49707; x1.

13-16. Ventral, anterior, posterior, and lateral view of syntype, University of Alberta Cb 278; x1.

17-20. Ventral, anterior, posterior, and lateral views of syntype, University of Alberta Cb 275; x1.

21-26. Ventral, anterior, posterior, lateral, dorsal views and a dorsal external mould of a complete, small specimen, GSC 63259, GSC locality 49695; x1.

27, 28. A dorsal view and the natural mould of the dorsal exterior of the same specimen, a syntype, University of Alberta Cb 274 and Cb 277; x1.

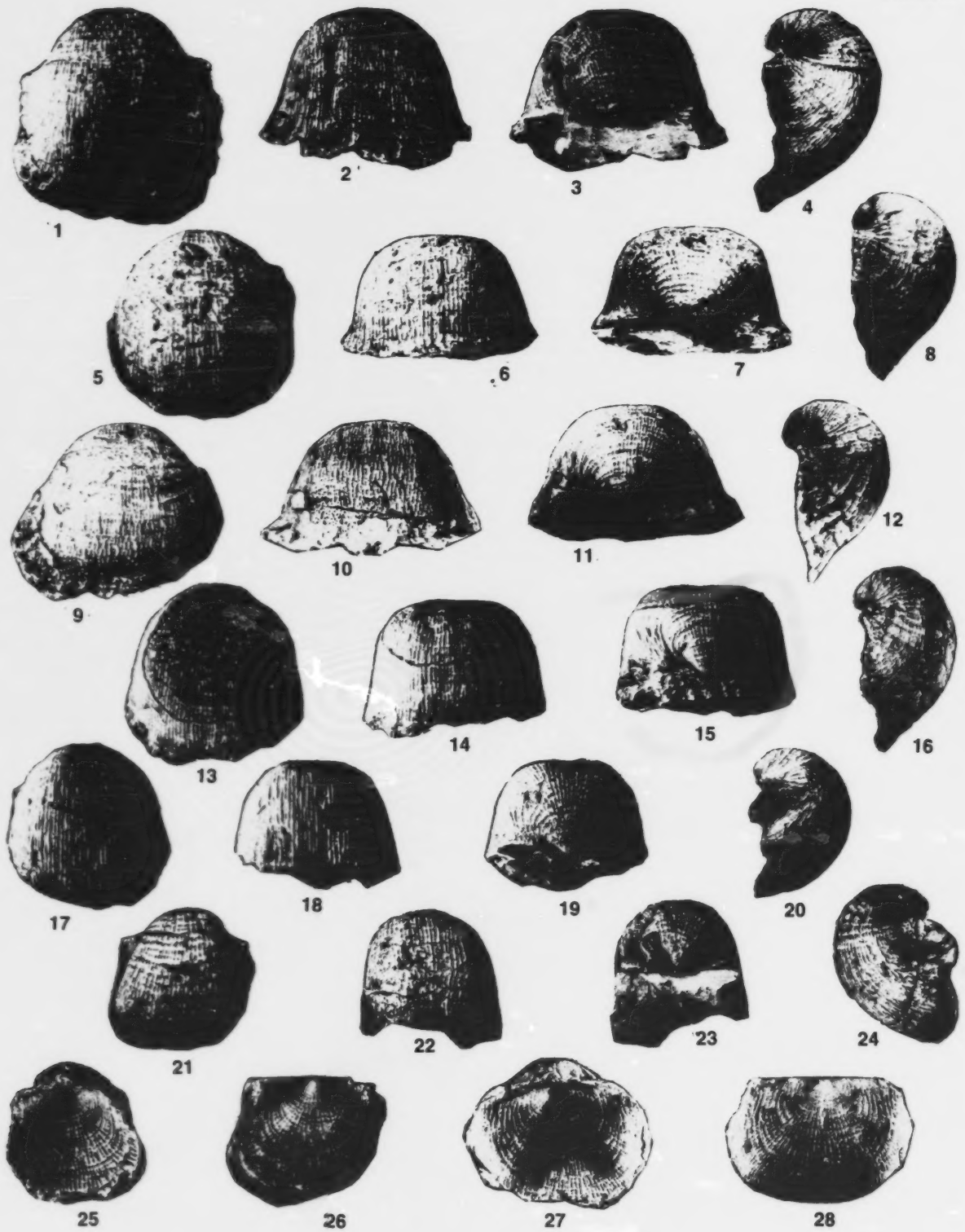
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PLATE 11

Figures 1-4. *Spinocarinifera* (*Spinocarinifera*) *arcuata* (Hall) (Page 29)

Ventral, anterior, lateral, and posterior views of a pedicle valve, GSC 63223, GSC locality C-4130; x1.

Figures 5, 6. *Setigerites newtonensis* (Moore) (Page 37)

Pedicle and brachial valves of a large, crushed specimen, GSC 63264, GSC locality C-57474; x1.

Figures 7-12. *Stegacanthia* cf. *S. bowsheri* Muir-Wood and Cooper (Page 33)

Ventral, posterior, and lateral views of two pedicle valves, GSC 63244 and 63245, GSC locality C-57469; x1.

Figures 13-19. *Marginatia ferrglenensis* (Weller) (Page 39)

13-16. Ventral, anterior, posterior, and lateral views of a pedicle valve, GSC 63275, GSC locality C-57469; x1.

17-19. Ventral, lateral, and anterior views of a natural mould of a brachial valve exterior, GSC 63276, GSC locality C-57469; x1.

Figures 20-23. *Flexaria* n. sp. (Page 39)

Ventral, lateral, anterior, and posterior views of a pedicle valve, GSC 10071, GSC locality 18527; x1.

Figures 24-32. *Pustula morrocreekensis* n. sp. (Page 38)

24-26. Ventral and dorsal views and the natural mould of the dorsal exterior, paratype, GSC 63268, GSC locality 49709; x1.

27, 28. Ventral and dorsal views of a large shell, paratype, GSC 63269, GSC locality 18555; x1.

29, 31. Ventral and dorsal views of the holotype, GSC 63270, GSC locality 49688; x1.

30, 32. Enlargements of the holotype; x2.

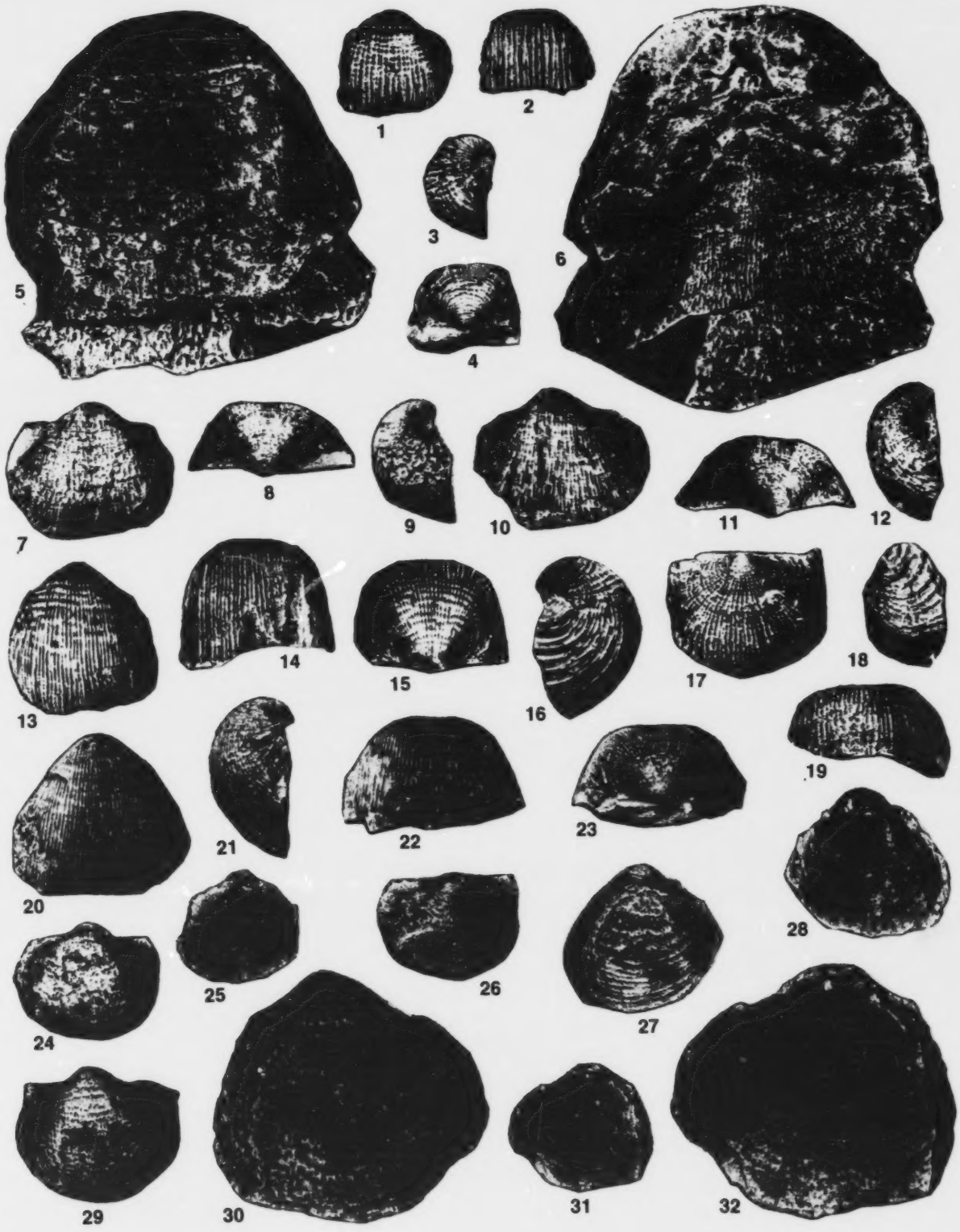
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PLATE 12

Figures 1-9. *Setigerites jasperensis* (Warren) (Page 36)

1, 2. Ventral and anterior views of a very large brachial valve interior, GSC 63260, GSC locality 37131; x1.5.

3-5. Ventral, anterior, and posterior views of another brachial valve interior from the same locality, GSC 63261; x 1.5.

6. Brachial valve interior, GSC 63262, GSC locality 31349; x1.5.

7-9. Ventral, anterior, and posterior views of a brachial valve interior, GSC 63263, GSC locality 49736; x1.5.

Figures 10-15. *Piloricilla desmetensis* n. gen. n. sp. (Page 34)

10. An immature brachial valve interior, paratype, GSC 63252, GSC locality C-7388; x2.

11, 12. Posterior and dorsal views of cardinal process of preceding specimen; x3.

13. A mature incomplete brachial valve interior, paratype, GSC 63253, GSC locality C-7388; x2.

14, 15. Posterior and dorsal views of the cardinal process of the preceding specimen; x3.

Figures 16, 17. *Spinocarinifera* (*Spinocarinifera*) *copiosa* n. sp. (Page 27)

Ventral and dorsal views of a silicified brachial valve, paratype, GSC 63222, GSC locality C-7388; x4.

Figure 18. *Stegacanthia* sp. (Page 33)

A very large brachial valve interior, GSC 63284, GSC locality 74893; x1.

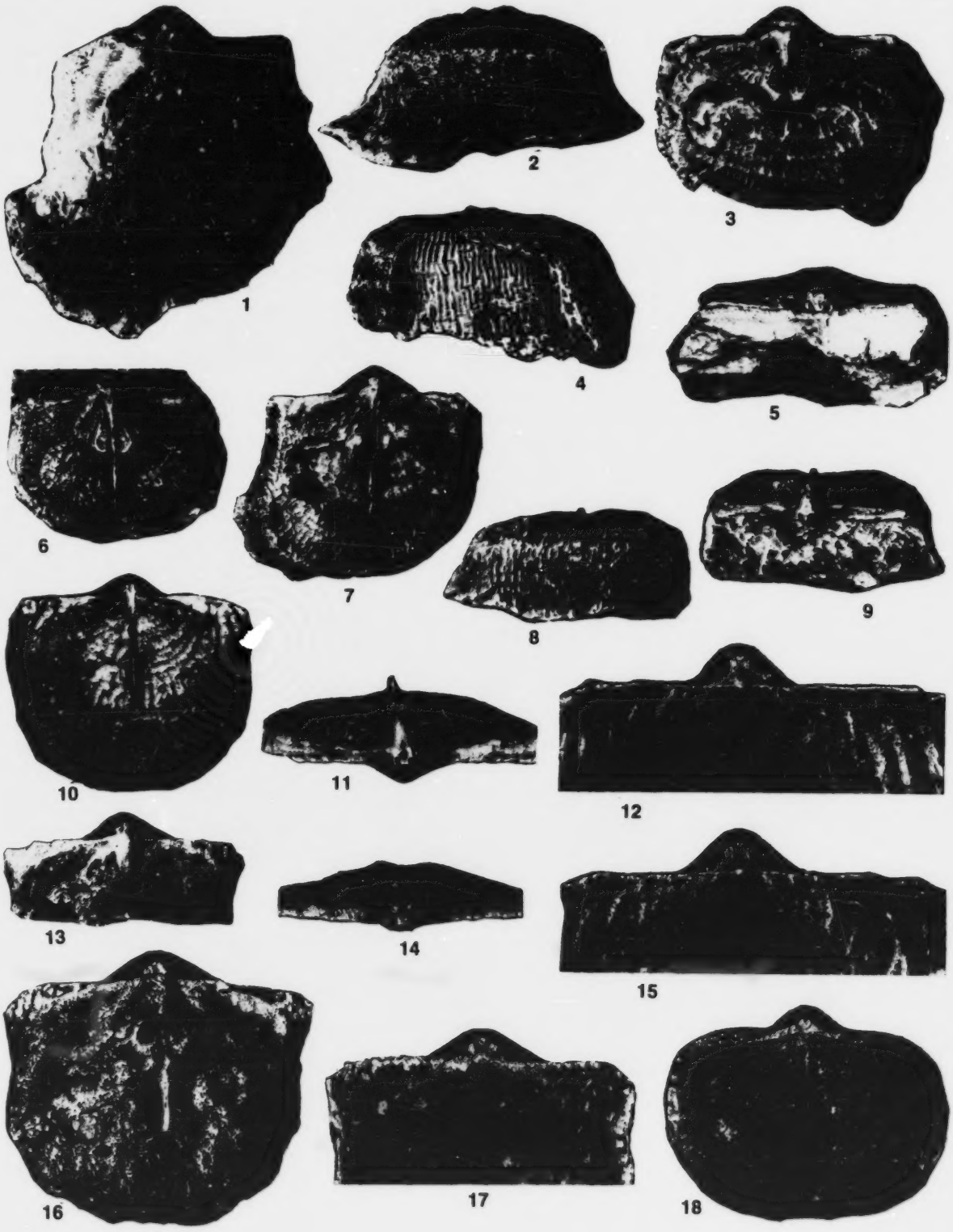
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PLATE 13

Figures 1-12. *Axiodeaneia usheri* (Brown) (Page 54)

1-4. Ventral, dorsal, lateral, and anterior views of a large, complete shell, University of Alberta Cb 361; x1.

5-8. Ventral, dorsal, lateral, and anterior views of referred specimen, GSC 63339; x1.

9-12. Ventral, dorsal, lateral, and anterior views of the holotype, GSC 9194; x1.

Figures 13-37. *Hemiplethorhynchus allani* (Warren) (Page 41)

13. Large brachial valve, paralectotype, University of Alberta Cb 299; x1.5.

14-17. Ventral, dorsal, lateral, and anterior views of the lectotype, University of Alberta Cb 300; x1.5.

18-21. Ventral, dorsal, lateral, and anterior views of GSC 9188, identified by Brown (1952) as a paratype of *Greenockia snaringensis* Brown but assigned here to *H. allani* (Warren); x1.5.

22-25. Ventral, dorsal, lateral, and anterior views of small, complete specimen, GSC 63285, GSC locality 36777; x1.5.

26-29. Ventral, dorsal, lateral, and anterior views of small, complete specimen, GSC 63286, GSC locality 36777; x1.5.

30-33. Ventral, dorsal, lateral, and anterior views of small, complete specimen, GSC 63287, GSC locality 66102; x 1.5.

34-37. Ventral, dorsal, lateral, and anterior views of small, complete specimen, GSC 63288, GSC locality 66102; x1.5.

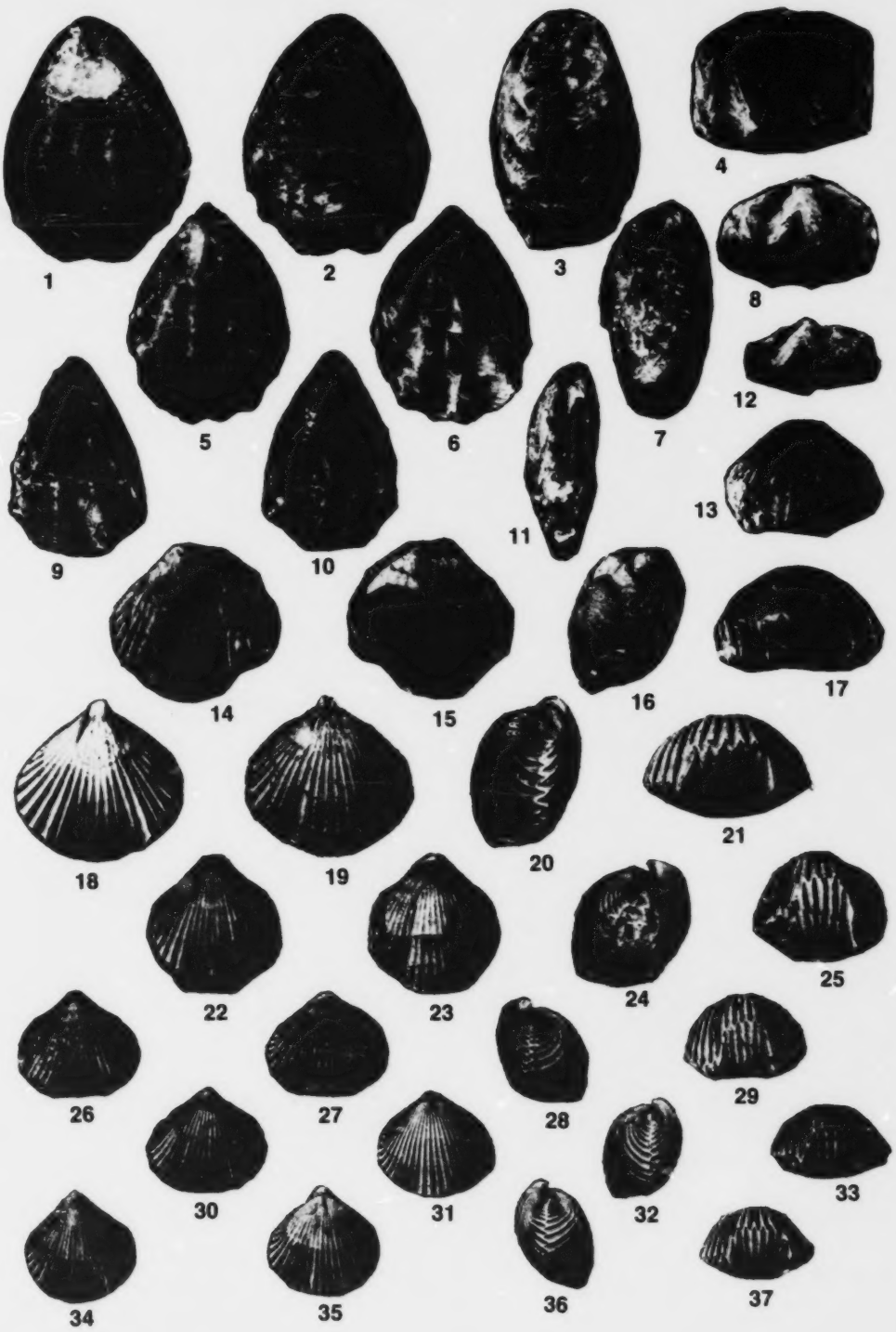
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PLATE 14

Figures 1-16. *Moorefieldella prisca* n. sp. (Page 44)

1-4. Ventral, dorsal, lateral, and anterior views of the holotype, GSC 63296, GSC locality 36755; x2.

5-8. Ventral, dorsal, lateral, and anterior view of paratype, GSC 63297-63299, GSC locality 36755; x2.

9-12. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63298, GSC locality 36755; x2.

13-16. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63299, GSC locality 36755; x2.

Figures 17-40. *Hemiplethorhynchus snaringensis* (Brown) (Page 43)

17-24. Ventral, dorsal, lateral, and anterior views of two very large specimens, GSC 63291 and 63292, respectively, lower Rundle Group (probably lower Shunda Formation), GSC locality 49717; x1.

25-28. Ventral, dorsal, lateral, and anterior views of three specimens, GSC 63293-63295, GSC locality 49753; x1.

29-32. Ventral, dorsal, lateral, and anterior views of the holotype, GSC 9183, GSC locality 49736; x1.

33-36. Ventral, dorsal, lateral, and anterior views of GSC 63294, GSC locality 49753; x1.

37-40. Ventral, dorsal, lateral, and anterior views of GSC 63295, GSC locality 49753; x1.

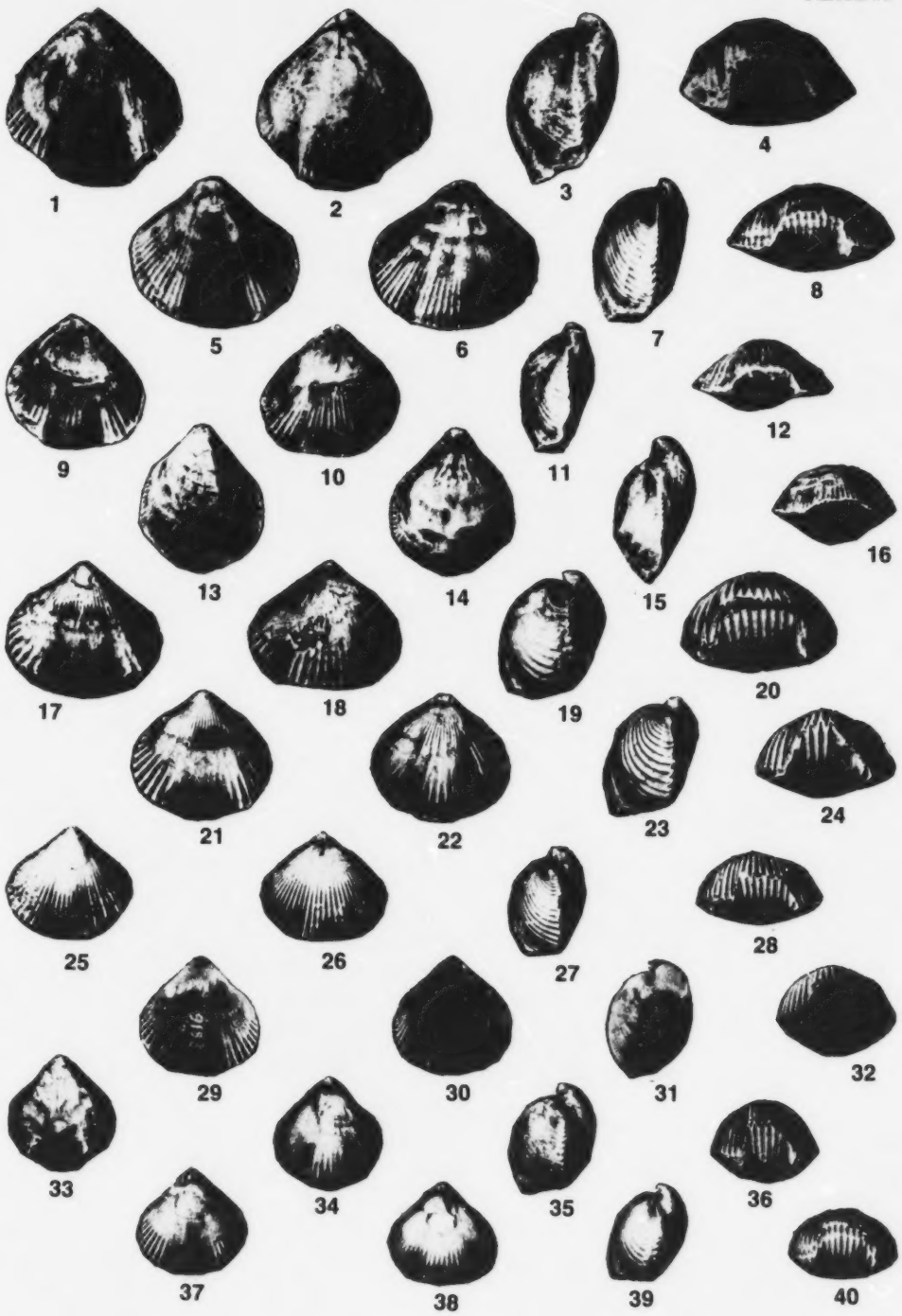
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PLATE 15

Figures 1-36. *Macropotamorhynchus insolitus* n. sp. (Page 49)

1-4. Ventral, dorsal, lateral, and anterior views of the holotype, GSC 63302, GSC locality C-4130; x2.

5-8. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63303, GSC locality C-4130; x2.

9-12. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63304, GSC locality 49707; x2.

13-16. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63305, GSC locality 49707; x2.

17-20. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63306, GSC locality 49707; x2.

21-24. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63307, GSC locality 49692; x2.

25-28. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63308, GSC locality 49692; x2.

29-32. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63309, GSC locality 49692; x2.

33-36. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63310, GSC locality 49692; x2.

Figures 37-48. *Hustedia circularis* (Miller) (Page 56)

37-40, 45. Ventral, dorsal, posterior, anterior, and lateral views of a large, silicified specimen, GSC 63340; x4.

41-44, 46. Ventral, dorsal, posterior, anterior, and lateral views of GSC 63341; x4.

47, 48. Ventral and dorsal views of a small specimen, GSC 63342; x4.

All from GSC locality C-7388.

Figures 49-52. *Athyridid* gen. et sp. indet. (Page 67)

Ventral, dorsal, anterior, and lateral views of a large specimen, GSC 10087a, GSC locality 18788; x1.

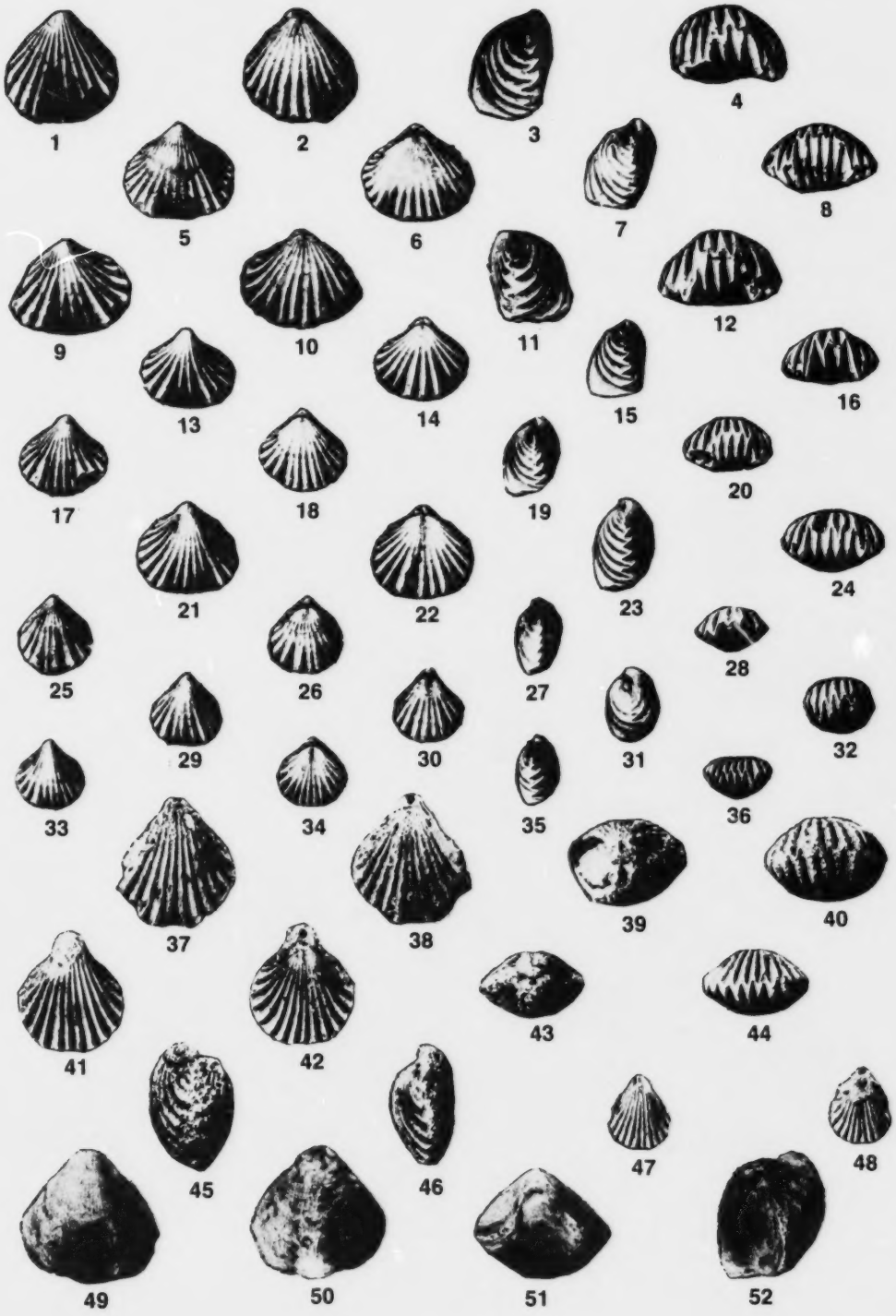
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PLATE 16

Figures 1-48. *Macropotamorhynchus curiosus* n. sp. (Page 45)

1-4. Ventral, dorsal, lateral, and anterior views of the holotype, GSC 63313; x2.

5-8. Ventral, dorsal, lateral, and anterior views of eleven paratypes, GSC 63314-63324, illustrating the extreme morphological variability in this species.

9-12. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63315; x2.

13-16. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63316; x2.

17-20. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63317; x2.

21-24. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63318; x2.

25-28. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63319; x2.

29-32. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63320; x2.

33-36. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63321; x2.

37-40. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63322; x2.

41-44. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63323; x2.

45-48. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63324; x2.

All from GSC locality 6857.

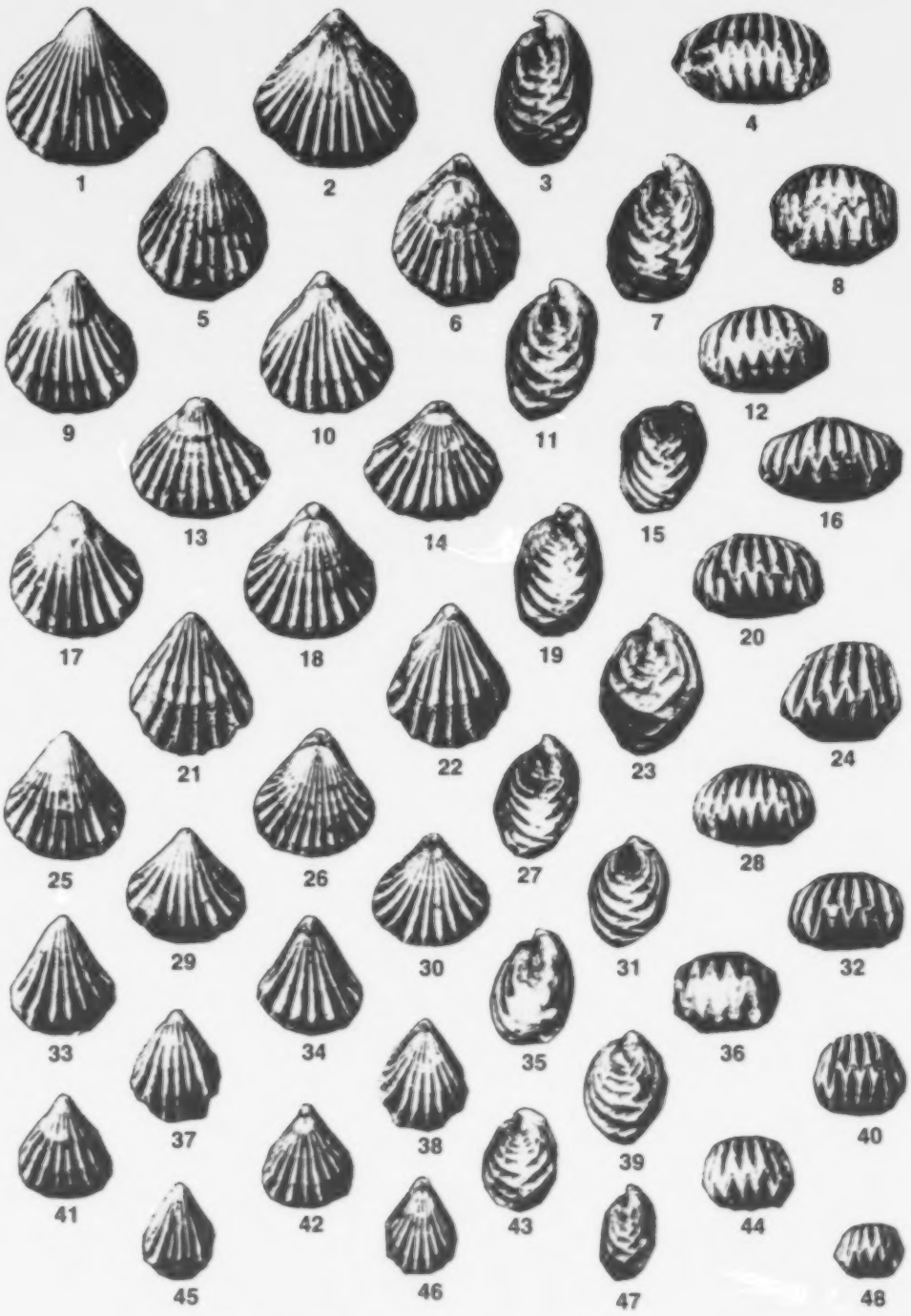
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PLATE 17

Figures 1-44. *Shumardella pygmaea* n. sp. (Page 52)

1-4. Ventral, dorsal, lateral, and anterior views of the large specimen identified by Nelson (1961) as *Shumardella* sp., University of Alberta Cb 360; x2.

5-8. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63327, GSC locality C-7383; x2.

9-12. Ventral, dorsal, lateral, and anterior views of holotype, GSC 63328, GSC locality C-7383; x2.

13-16. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63329, GSC locality C-7383; x2.

17-20. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63330, GSC locality C-7383; x2.

21-24. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63331, GSC locality C-7383; x2.

25-28. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63332, GSC locality C-7383; x2.

29-32. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63333, GSC locality C-7383; x2.

33-36. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63334, GSC locality C-7383; x2.

37-40. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63335, GSC locality C-7383; x2.

41-44. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63336, GSC locality C-7383; x2.

45-48. Ventral, dorsal, lateral, and anterior views of paratype, GSC 63337, GSC locality C-7383; x2.

Figures 45-48 *Ningbingella*? cf. *Rhynchonella boonensis* (Shumard) (Page 54)

Ventral, dorsal, lateral, and anterior views, GSC 63338, GSC locality C-86546; x1.

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PLATE 18

Figures 1-16. *Eumetria osagensis* (Swallow) (Page 56)

1-4. Ventral, dorsal, anterior, and lateral views of GSC 63343, GSC locality 49736; x1.5.

5-8. Ventral, dorsal, anterior, and lateral views of GSC 63344, GSC locality 49736; x1.5.

9-12. Ventral, dorsal, anterior, and lateral views of GSC 63345, GSC locality 49740; x1.5.

13-16. Ventral, dorsal, anterior, and lateral views of GSC 63346, GSC locality 49753; x1.5.

Figures 17-40. *Composita humilis* (Girty) (Page 62)

Ventral, dorsal, anterior, and lateral views of a growth series of six specimens, GSC 63359-63364, GSC locality 68573; x2.

17-20. GSC 63359.

21-24. GSC 63360.

25-28. GSC 63361.

29-32. GSC 63362.

33-36. GSC 63363.

37-40. GSC 63364.

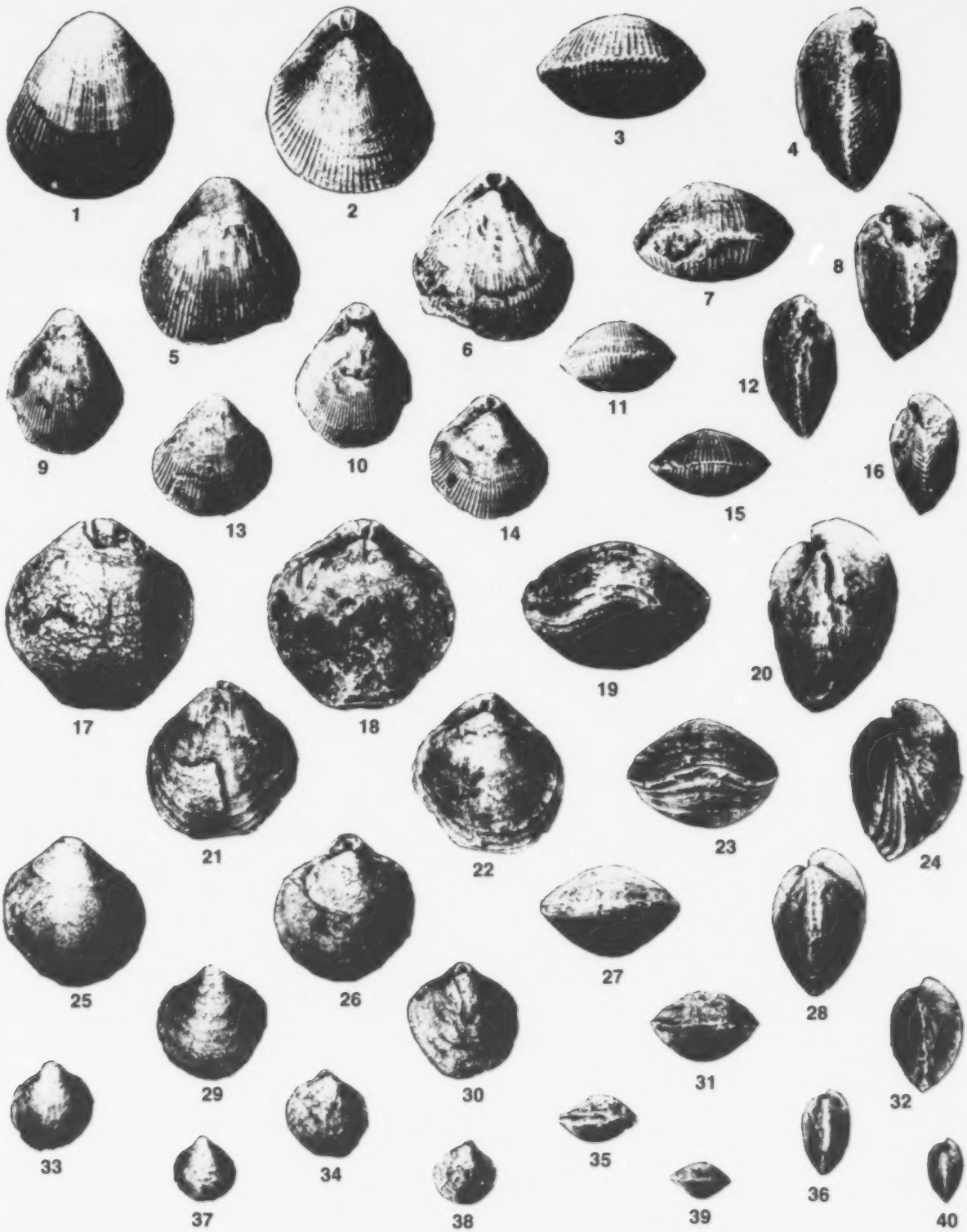
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PLATE 19

Figures 1-16. *Cleiothyridina lata* Shimer (Page 58)

1-4. Ventral, dorsal, anterior, and lateral views of GSC 63348, GSC locality 49723; x1.

5-8. Ventral, dorsal, anterior, and lateral views of GSC 63349, GSC locality 49690; x1.

9-12. Ventral, dorsal, anterior, and lateral views of GSC 10085a, from GSC locality 18790; x1.

13-16. Ventral, dorsal, anterior, and lateral views of the holotype, GSC 4841; x1.

Figures 17-23. *Cleiothyridina miettensis* n. sp. (Page 61)

17-20. Ventral, dorsal, anterior, and lateral views of a silicified pedicle valve, syntype GSC 63355.

21-23. Dorsal, anterior, and lateral views of a silicified brachial valve, syntype GSC 63356.
Both from GSC locality C-28282; x3.

Figures 24-27. *Cleiothyridina harkeri* n. sp. (Page 60)

Ventral, dorsal, anterior, and lateral views of the holotype, GSC 63354, GSC locality 18527; x1.

Figures 28-31. *Pseudopentagonia* cf. *P. injensis* Beznosova (Page 67)

Ventral, dorsal, anterior, and lateral views of a complete but spalled specimen, GSC 63379, GSC locality 49746; x2.

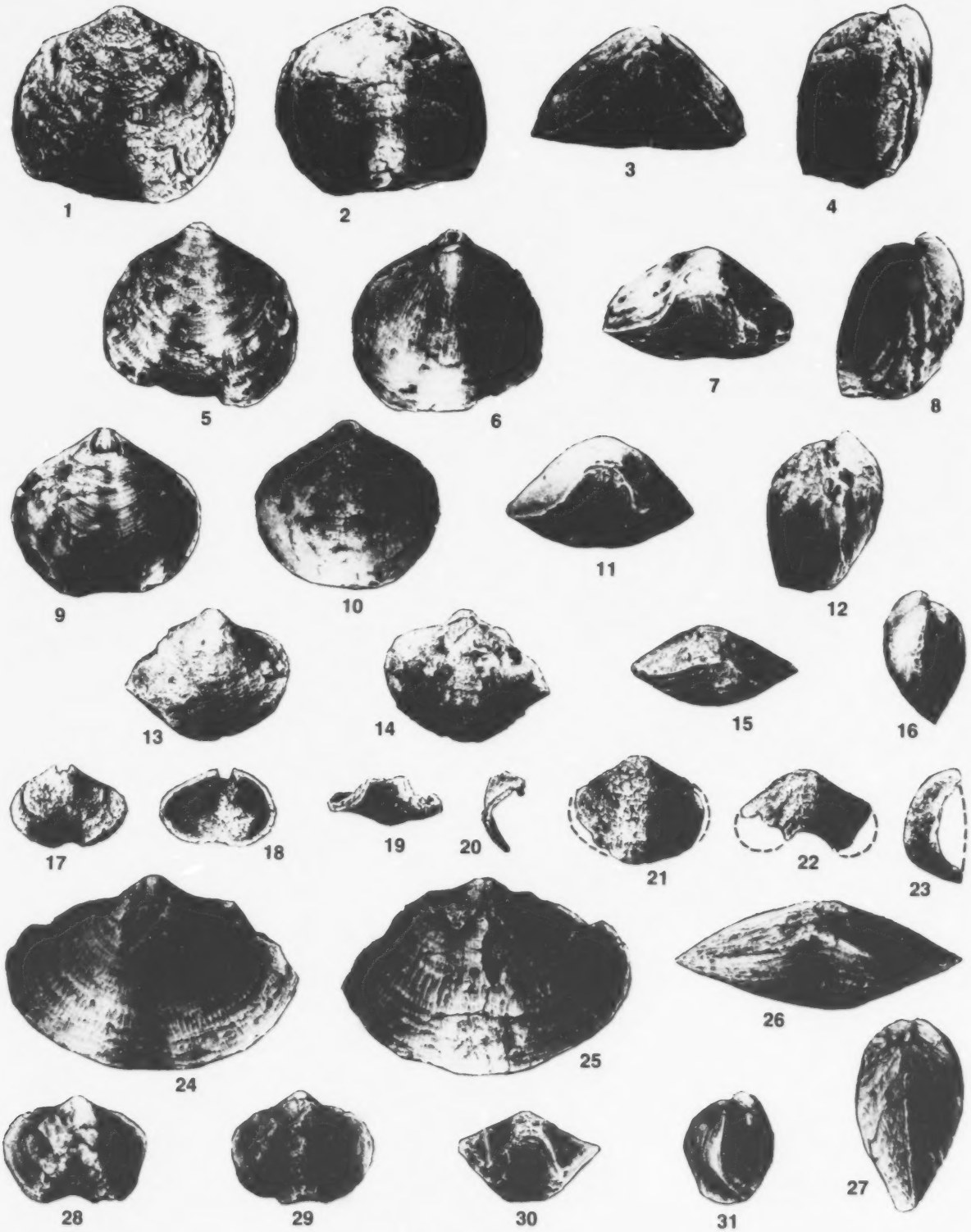
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PLATE 20

Figures 1-12. *Cleiothyridina tenuilineata* (Rowley) (Page 60)

1-4. Ventral, dorsal, anterior, and lateral views of GSC 63351, GSC locality 49690; x3.

5-8. Ventral, dorsal, anterior, and lateral views of GSC 63352, GSC locality 49690; x3.

9-12. Ventral, dorsal, anterior, and lateral views of GSC 63353, GSC locality C-11787; x3.

Figures 13-28. *Composita prolixa* n. sp. (Page 66)

13-16. Ventral, dorsal, anterior, and lateral views of the holotype, GSC 63371.

17-28. Ventral, dorsal, anterior, and lateral views of three paratypes, GSC 63372-63374.
All from GSC locality 49705; x1.5.

Figures 29-44. *Composita immatura* (Girty) (Page 64)

29-32. Ventral, dorsal, anterior, and lateral views of complete specimen, GSC 63366, GSC locality 19992; x1.5.

33-36. Ventral, dorsal, anterior, and lateral views of complete specimen, GSC 63367, GSC locality 18790; x1.5.

37-40. Ventral, dorsal, anterior, and lateral views of complete specimen, GSC 63368, GSC locality 19992; x1.5.

41-44. Ventral, dorsal, anterior, and lateral views of complete specimen, GSC 63369, GSC locality 49699; x1.5.

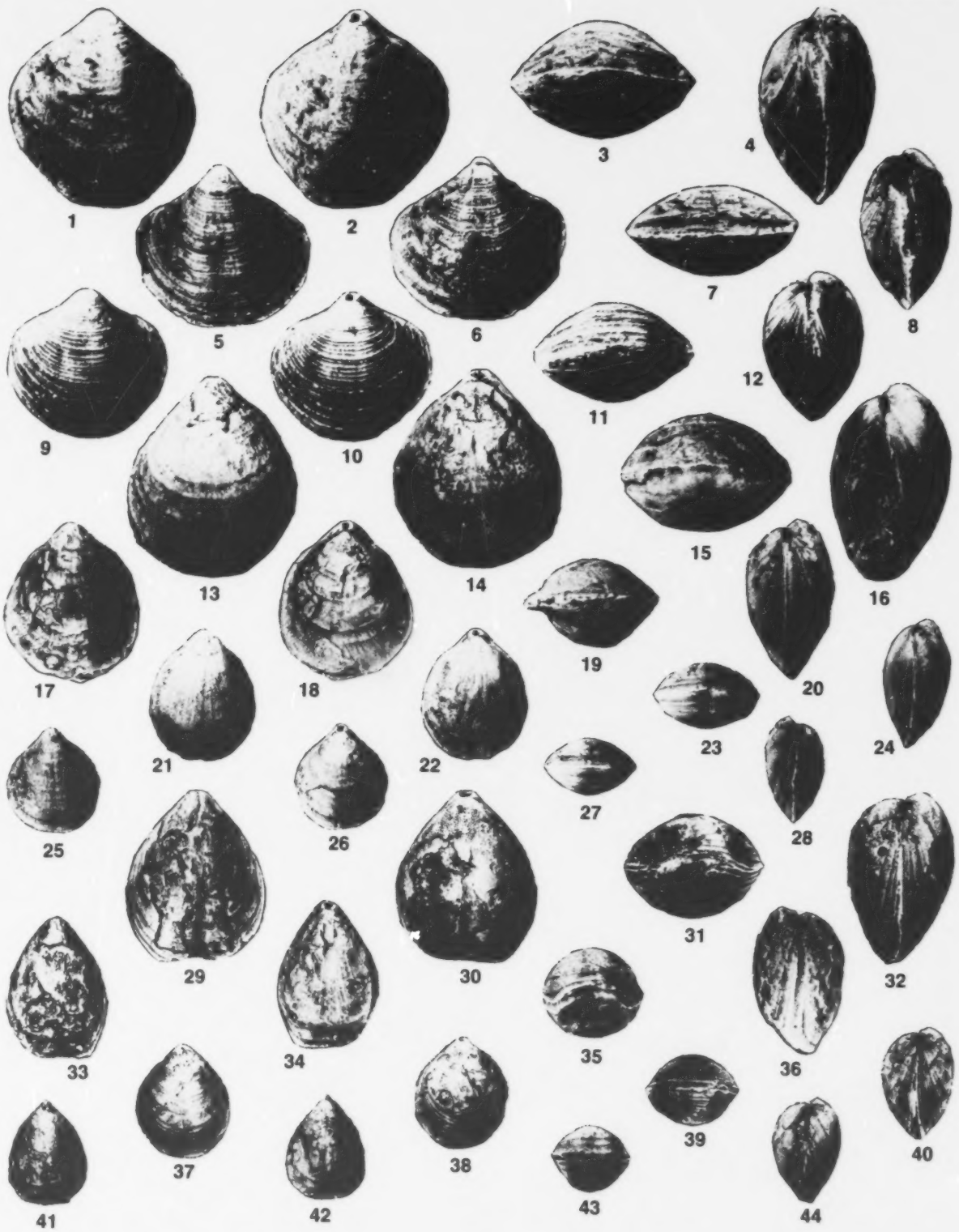
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PLATE 21

Figures 1-16. *Composita* cf. *C. oblonga* (Tolmachoff) (Page 66)

1-4. Ventral, dorsal, anterior, and lateral views of complete specimen GSC 63375, GSC locality 31347; x1.5.

5-8. Ventral, dorsal, anterior, and lateral views of complete specimen GSC 63376, GSC locality 31347; x1.5.

9-12. Ventral, dorsal, anterior, and lateral views of complete specimen GSC 63377, GSC locality 31347; x1.5.

13-16. Ventral, dorsal, anterior, and lateral views of complete specimen GSC 63378, GSC locality 31347; x1.5.

Figures 17-36. *Composita athabaskensis* Warren (Page 61)

17-20. Ventral, dorsal, anterior, and lateral views of a very large specimen, GSC 63357, GSC locality 49704; x1.

21-36. Ventral, dorsal, anterior, and lateral views of Warren's four best syntypes, University of Alberta Cb 288, Cb 292, Cb 289, and Cb 294; x1.

21-24. Syntype Cb 288.

25-28. Syntype Cb 292.

29-32. Syntype Cb 289.

33-36. Syntype Cb 294.

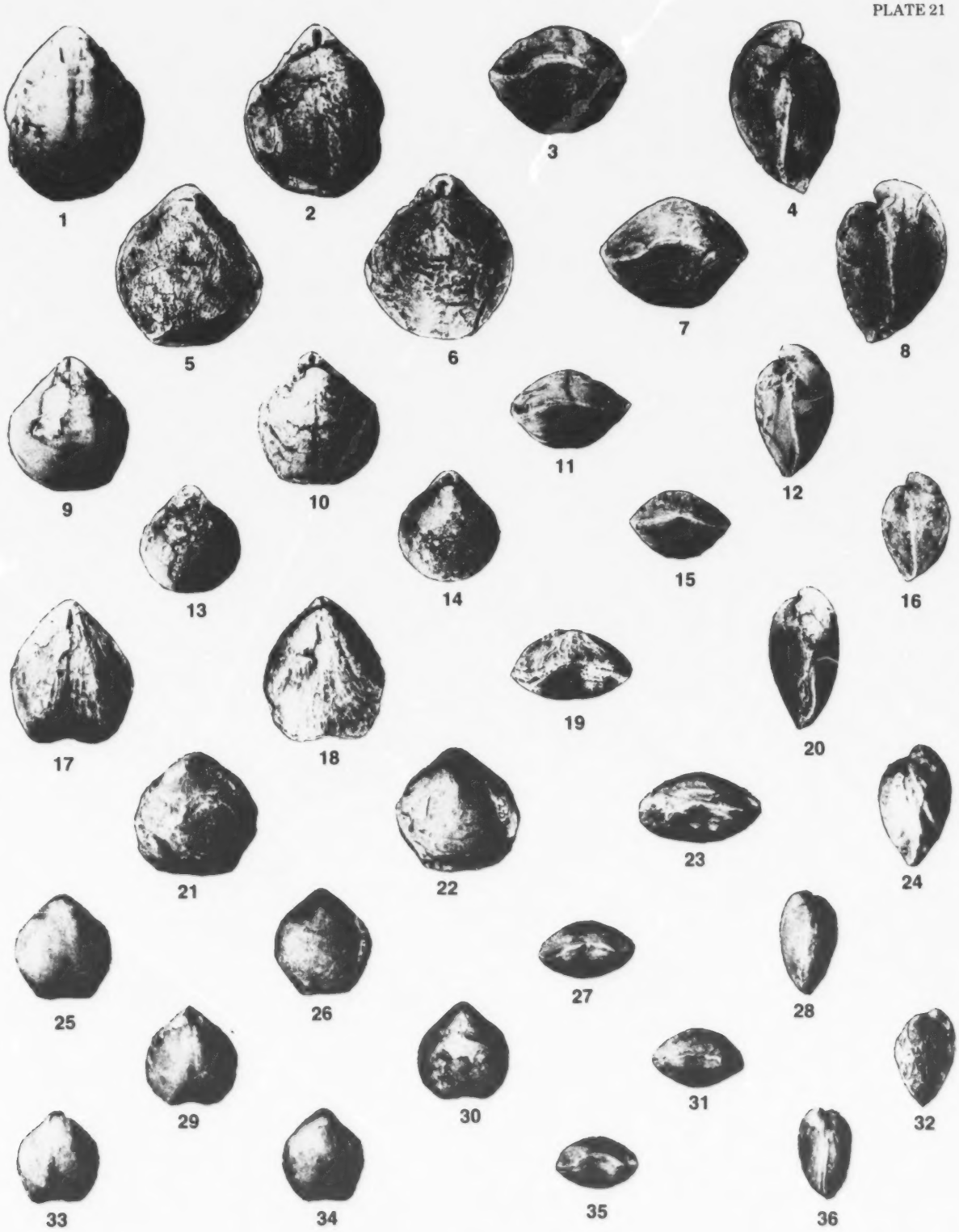
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PLATE 22

Figures	1-8.	*Calvustrigis rutherfordi* (Warren)	(Page 68)
	1, 5.	Pedicle and brachial valves, GSC 63383 and 63384, respectively, GSC locality 49723; x1.	
	2-4.	Ventral, dorsal, and lateral views of Warren's largest syntype, University of Alberta Cb 297; x1.	
	6-8.	Ventral, dorsal and anterior views of another syntype, University of Alberta Cb 296; x1.	
Figures	9-27.	*Podtsheremia? albertensis* (Warren)	(Page 80)
	9.	A large pedicle valve, GSC 63417, GSC locality 49695; x1.	
	10-17.	Ventral, dorsal, anterior, and lateral views of two nearly complete specimens, GSC 63418 and 63419, respectively, GSC locality 49695; x1.	
	18-25.	Ventral, dorsal, anterior, and lateral views of two syntypes, University of Alberta Cb 285 and Cb 281, respectively; x1.	
	26, 27.	Two pedicle valves, syntypes, University of Alberta Cb 282 and Cb 283; x1.	
Figures	28, 29, 33, 34.	*Punctospirifer solidirostris* (White)	(Page 87)
	28, 29.	Two pedicle valves, GSC 63440 and 63441, GSC localities 49727 and 49706, respectively; x2.	
	33, 34.	Ventral and dorsal views of a nearly complete specimen, GSC 63442, GSC locality 49719; x2.	
Figures	30-32.	*Punctospirifer* cf. *P. subtexta* (White)	(Page 87)
		Ventral, dorsal, and anterior views of a slightly crushed specimen, GSC 10066, GSC locality 18527; x2.	

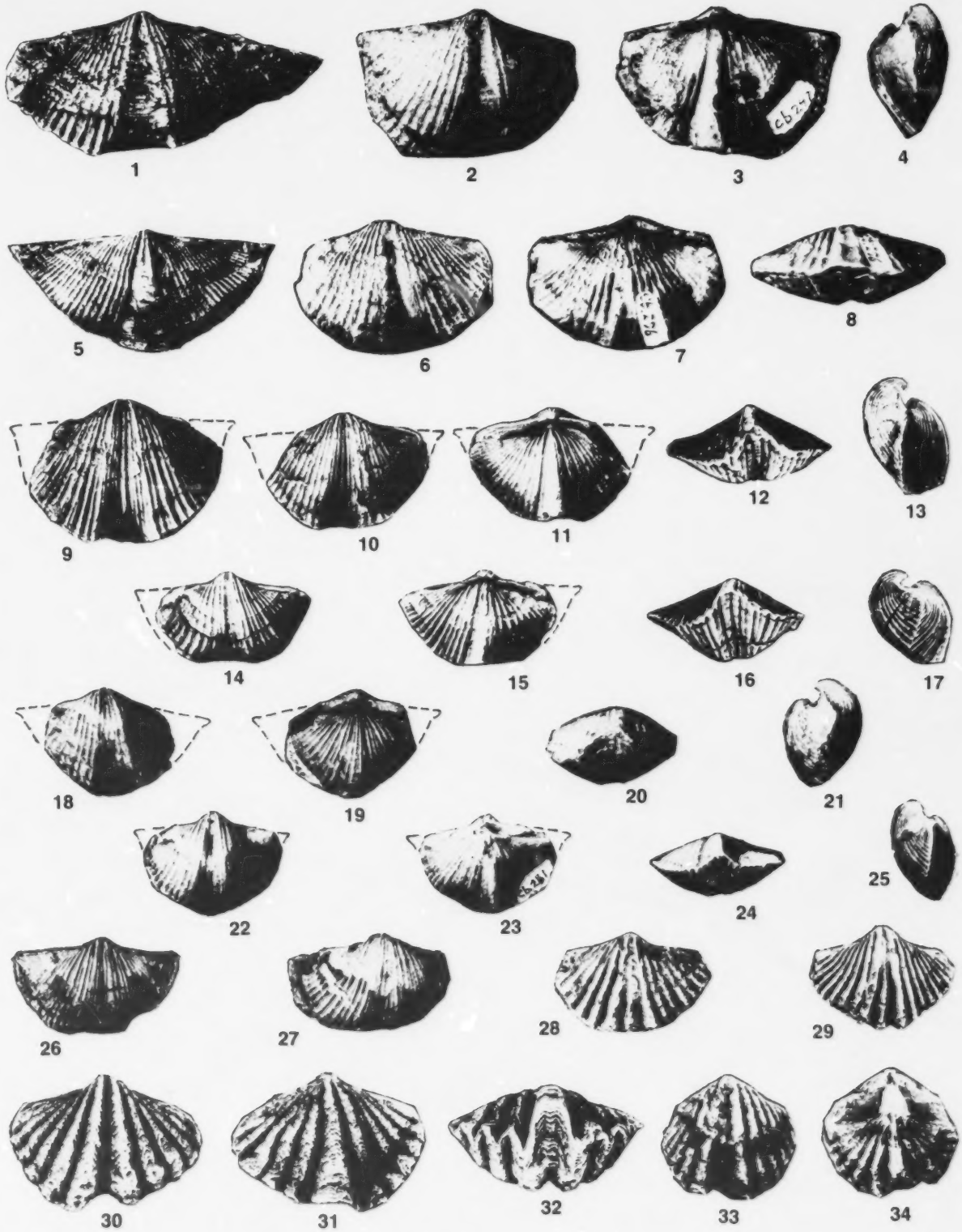
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PLATE 23

Figures	1-13, 22-25.	*Unispirifer minnewankensis* (Shimer)	(Page 75)
	1.	Holotype, a small, immature pedicle valve, GSC 4630; x2.	
	2, 5.	Interior and exterior views of a large, silicified brachial valve, GSC 63402, GSC locality 68593; x1.5 and x1, respectively.	
	3.	Pedicle valve interior, GSC 63403, GSC locality 68593; x1.5.	
	4.	Large pedicle valve, GSC 63404, GSC locality 57859; x1.	
	6-9.	Ventral, dorsal, anterior, and lateral views of nearly complete specimens, GSC 63405, GSC locality 18527; x1.	
	10-13.	Ventral, dorsal, anterior, and lateral views of nearly complete specimen, GSC 63406, GSC locality 57859; x1.	
	22-25.	Ventral, dorsal, anterior, and lateral views of a small specimen, GSC 63407, GSC locality 49707; x1.5.	
Figures	14-19.	*Voiseyella texana* (Carter)	(Page 70)
	14-17.	Ventral, dorsal, anterior, and lateral views of a spalled specimen, GSC 63386, GSC locality 73526; x2.	
	18, 19.	Ventral and dorsal views of the same specimen; x1.	
Figures	20, 21, 26-33.	*Prospira* cf. *P. albapinensis* (Hall and Whitfield)	(Page 71)
	20, 21.	Ventral and dorsal views of a large, incomplete shell, GSC 63387, GSC locality C-86543; x1.5.	
	26-33.	Ventral, dorsal, anterior, and lateral views of two incomplete shells, GSC 63388 and 63389 respectively, GSC locality 49692; x1.5.	

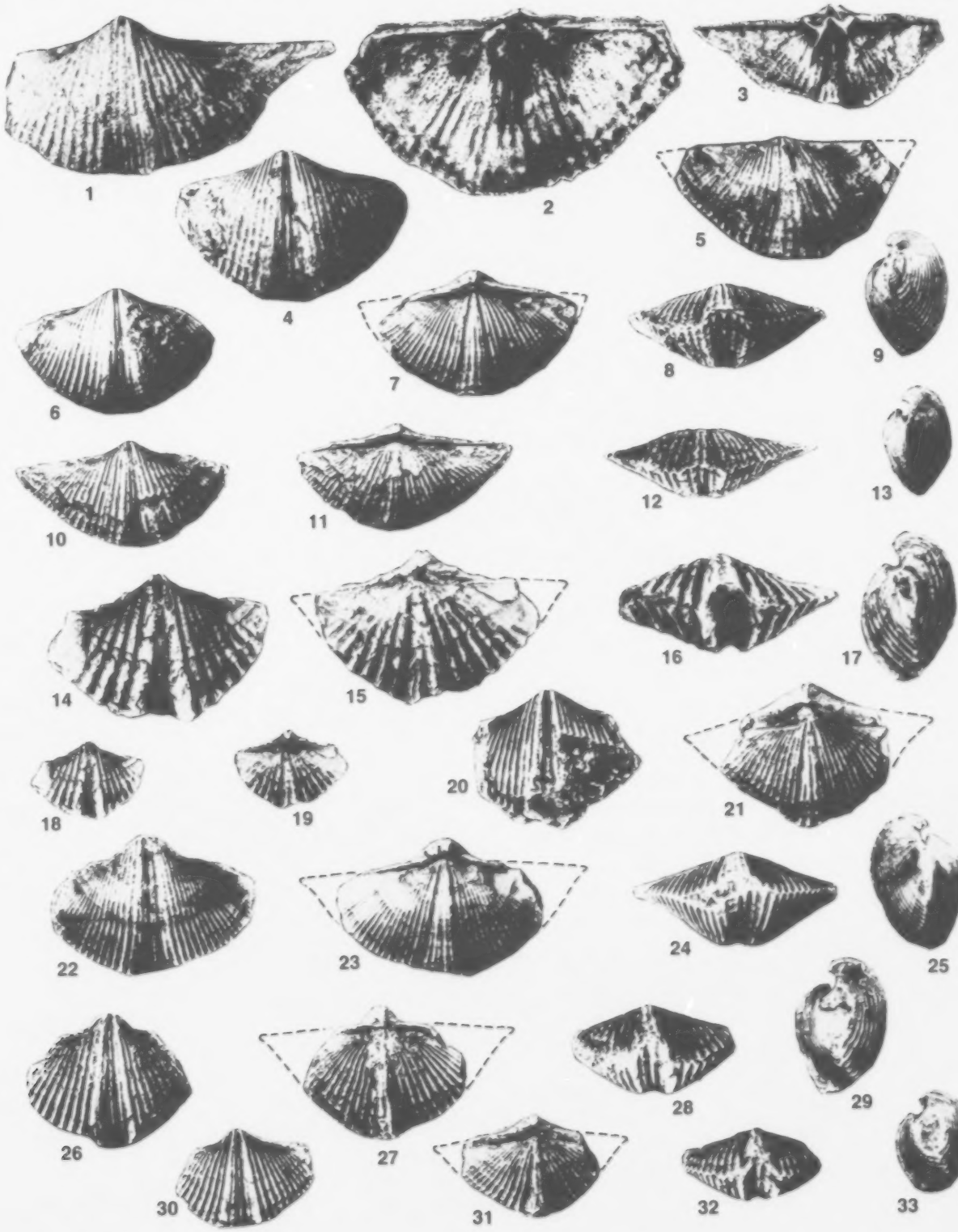
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PLATE 24

Figures	1-6.	*Spirifer mountraensis* n. sp.	(Page 76)
	1-5.	Ventral, dorsal, lateral, anterior, and posterior views of the holotype, GSC 63410, GSC locality 57859; x1.	
	6.	Pedicle valve, GSC 13448, GSC locality 18527; x1.	
Figures	7-10.	*Spirifer cascadensis* Warren	(Page 79)
	7.	Lectotype, a pedicle valve, GSC 8909; x1.	
	8.	Brachial valve, paralectotype, GSC 8909a; x1.	
	9, 10.	Pedicle and brachial valves, GSC 63415 and 63416, respectively, GSC locality 49734; x1.	
Figures	11-15.	*Unispirifer rundlensis* (Warren)	(Page 76)
	11, 12.	Ventral and dorsal views of the best syntype, GSC 8908; x1.5.	
	13.	Dorsal view of another syntype, GSC 8908a; x1.5. The types are from the lower Livingstone Formation at Mount Rundle.	
	14, 15.	Pedicle and brachial valves, GSC 10082a and 10082c, respectively, Banff Formation at Mount Rundle, GSC locality 18293; both x1.	
Figure	16.	*Unispirifer* cf. *U. rundlensis* (Warren)	(Page 76)
		Pedicle valve, GSC 63408, GSC locality 49690; x1.5.	

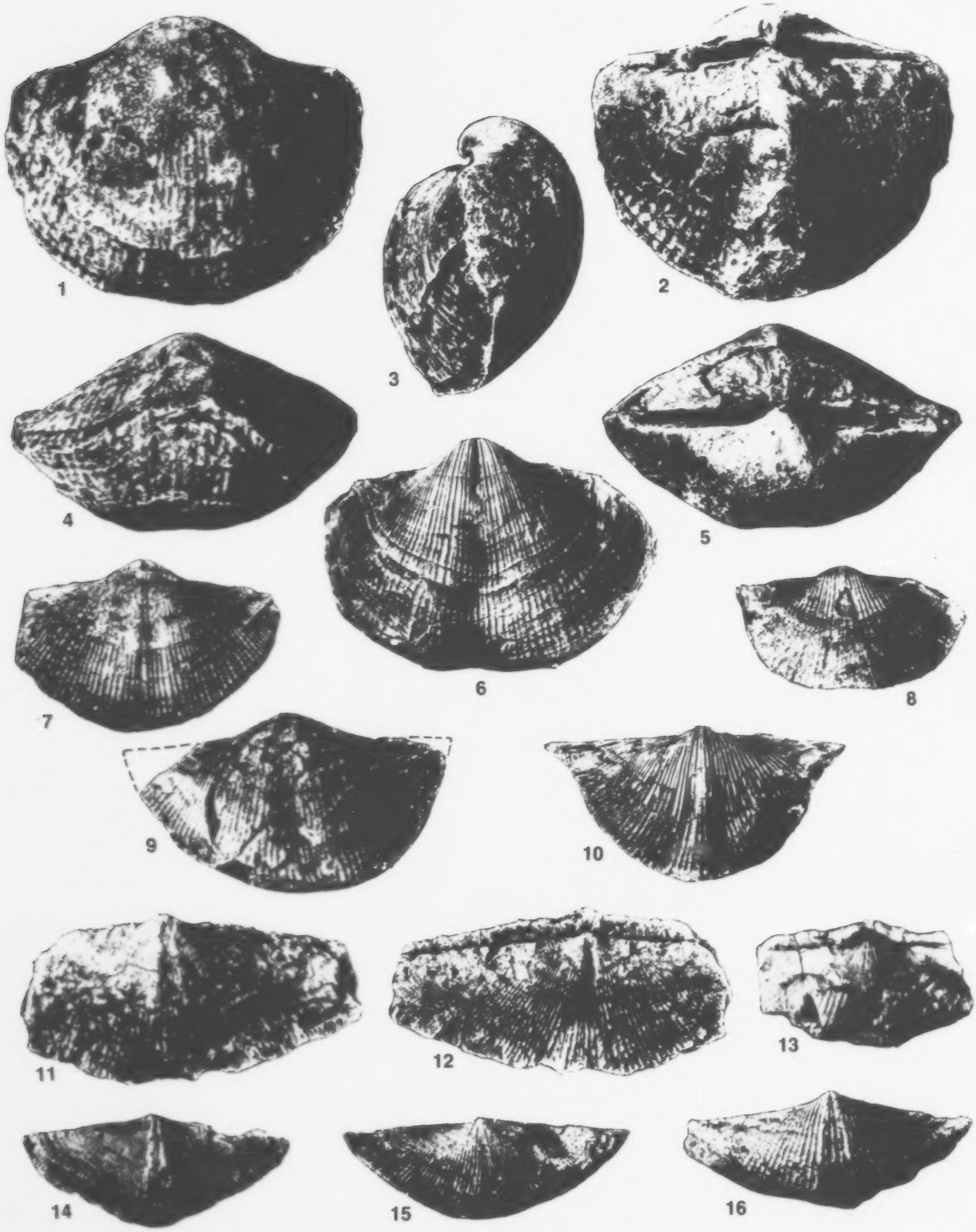
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PLATE 25

Figures 1-23. *Spirifer esplanadensis* Brown (Page 77)

1-4. Ventral, dorsal, anterior, and lateral views of the holotype, GSC 9199; x1.

5-8. Ventral, dorsal, anterior, and lateral views of a paratype, GSC 9200; x1.

9-13. Ventral, dorsal, anterior, posterior, and lateral views of complete shell, GSC 63411, GSC locality 49692; x1.

14-18. Ventral, dorsal, anterior, posterior, and lateral views of complete shell, GSC 63412, GSC locality 74931; x1.

19-23. Ventral, dorsal, anterior, posterior, and lateral views of complete shell, GSC 63413, GSC locality 66038; x1.

Figures 24-38. *Unispirifer greenockensis* (Brown) (Page 72)

24. Holotype, large pedicle valve, GSC 9204; x1.

25. Pedicle valve, GSC 63394, GSC locality 74866; x1.

26. Pedicle valve, GSC 63395, GSC locality C-86542; x1.

27. Pedicle valve, GSC 63396, GSC locality 40263; x1.

28, 29. Ventral and dorsal views of a nearly complete but slightly crushed shell, GSC 63398, GSC locality 49706; x1.

30-33. Ventral, dorsal, anterior, and lateral views of a small shell, GSC 63399, GSC locality 49692; x1.

34-37. Ventral, dorsal, anterior, and lateral views of an asymmetrical shell with a distorted ventral beak, GSC 63400, GSC locality C-86542; x1.

38. Pedicle valve, GSC 63397, GSC locality 49726; x1.

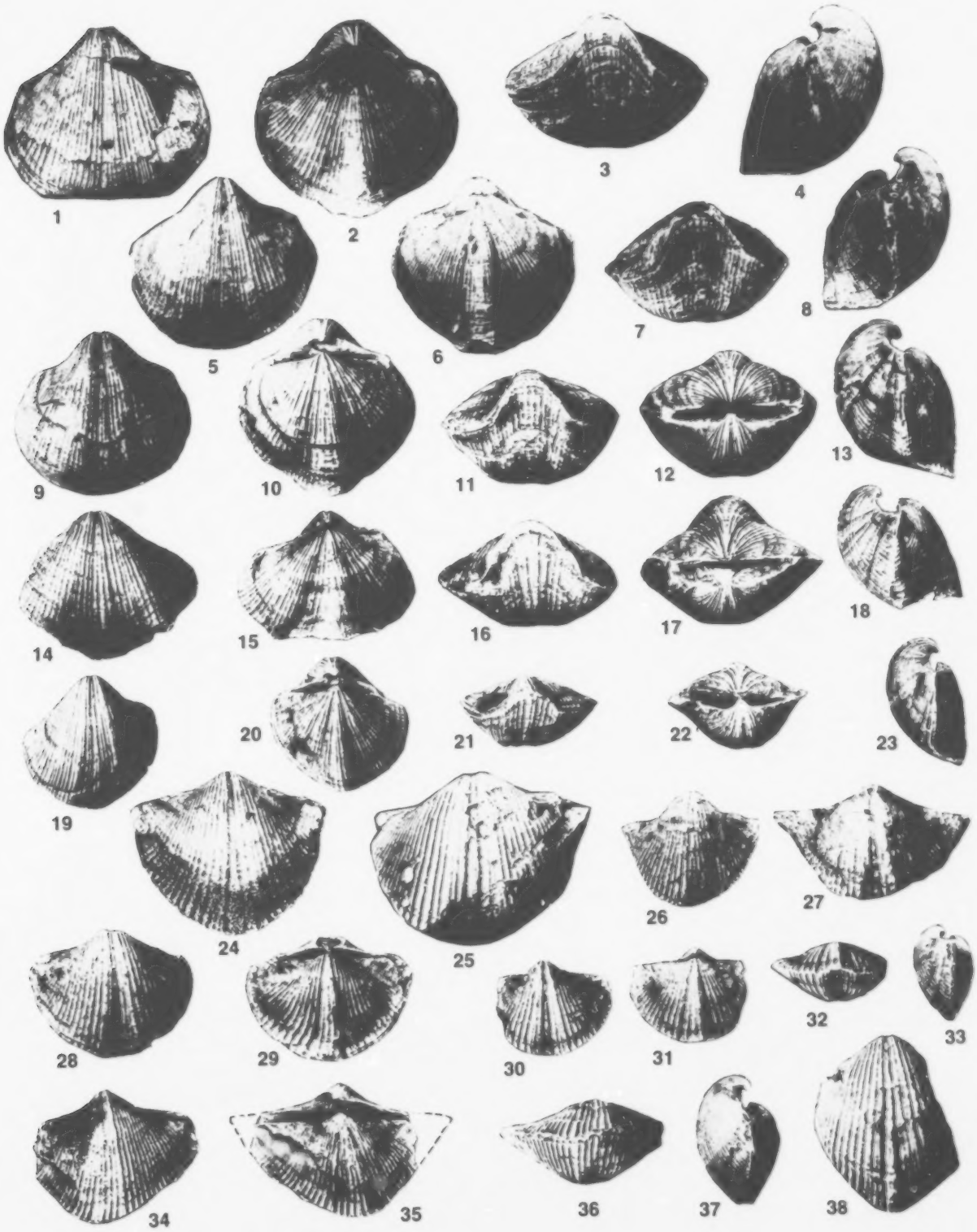
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PLATE 26

Figures 1-6. *Skelidorygma bamberi* n. sp. (Page 82)

1-4. Pedicle valve exterior (x1), and three enlarged interior views (x2) of the silicified holotype, GSC 63424, GSC locality C-4132.

5. Large, elongate, slightly crushed pedicle valve, paratype, GSC 10063, GSC locality 18527; x1.

6. Transverse, crushed, silicified pedicle valve, paratype, GSC 63425, GSC locality C-4132; x1.

Figures 7, 8. *Brachythyris chouteauensis* (Weller) (Page 82)

7. Large, spalled pedicle valve, GSC 63421, GSC locality 73526; x1.

8. Pedicle valve, GSC 63422, GSC locality 49721; x1.

Figures 9-14. *Brachythyris* cf. *B. chouteauensis* (Weller) (Page 82)

9, 10. Ventral and dorsal views of GSC 63423, GSC locality C-11787; x1.

11-14. Enlarged ventral, dorsal, anterior, and lateral views of the same specimen; x2.

Figures 15-26. *Prospira fessaulacis* n. sp. (Page 71)

15-18. Ventral, dorsal, anterior, and lateral views of the silicified holotype, GSC 63390, GSC locality 68448; x1.5.

19. Enlarged dorsal view of a silicified paratype, GSC 63391, GSC locality 68448; x2.

20-22. Ventral, dorsal, and lateral views of paratype, GSC 63392, GSC locality 68567; x1.5.

23-26. Ventral, dorsal, anterior, and lateral views of a slightly distorted paratype, GSC 63393, GSC locality 49688; x1.5.

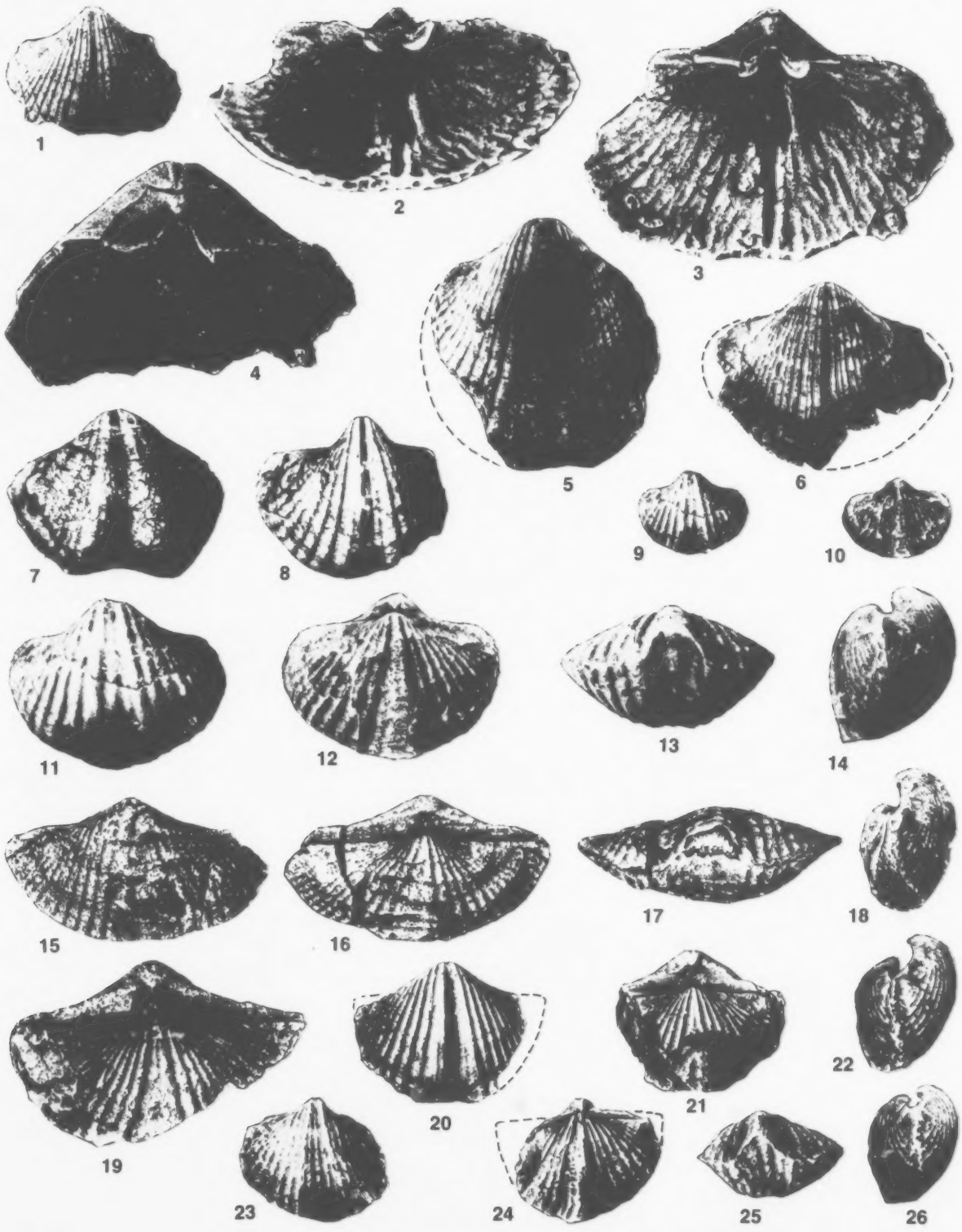
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PLATE 27

Figures 1-11. *Torynifer eufastigium* n. sp. (Page 83)

1-5. Ventral, dorsal, anterior, posterior, and lateral views of the holotype, GSC 63428, GSC locality 68486; x1.

6-10. Ventral, dorsal, anterior, posterior, and lateral views of a nearly complete paratype, GSC 63429, GSC locality 49729; x1.

11. A large pedicle valve, paratype, GSC 63430, GSC locality 18559; x1.

Figures 12-16. *Torynifer pseudolineatus* (Hall) (Page 83)

12-15. Ventral, dorsal, anterior, and lateral views of a nearly complete specimen, GSC 63426, GSC locality C-57468; x1.

16. A pedicle valve, same locality, GSC 63427; x1.

Figures 17-26. *Kitakamithyris cooperensis* (Swallow) (Page 85)

17-21. Ventral, dorsal, anterior, posterior, and lateral views of complete shell, GSC 63432, GSC locality C-86544; x1.

22-26. Ventral, dorsal, anterior, posterior, and lateral views of complete shell, GSC 63433, GSC locality 31350; x1.

Figures 27-42. *Eomartiniopsis rostrata* (Girty) (Page 85)

27-30. Ventral, dorsal, posterior, and lateral views of a large specimen, GSC 63434.

31-42. Ventral, dorsal, anterior, and lateral views of three complete specimens, GSC 63435, 63436, and 63437, respectively.

All from GSC locality 36777; x1.

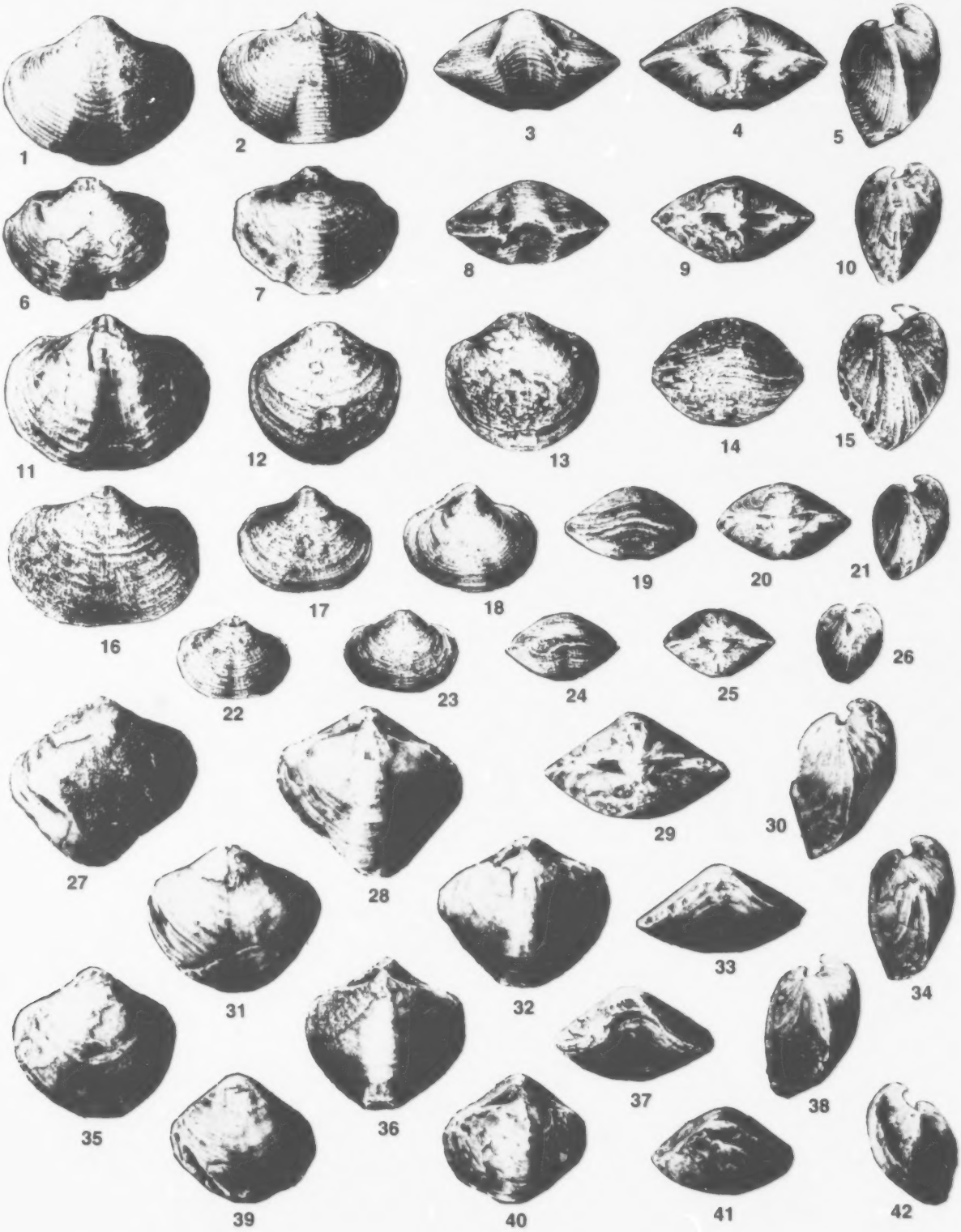
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PLATE 28

Figures 1-12. *Verkhotomia jucunda* n. sp. (Page 88)

1-5. Ventral, dorsal, lateral, anterior, and posterior views of a large paratype, GSC 63445, GSC locality C-57470; x1.

6-9. Ventral, posterior, dorsal, and lateral views of the holotype, GSC 63446, GSC locality 57859; x1.

10. Enlarged, oblique view of ventral interarea of holotype; x2.

11, 12. Ventral and dorsal interiors of silicified paratypes, GSC 63447 and 64448, respectively, GSC locality C-4132; x2.

Figures 13-22. *Syringothyris* cf. *S. hannibalensis* (Swallow) (Page 87)

13-17. Ventral, dorsal, anterior, posterior, and lateral views of complete specimen, GSC 63443, GSC locality 49711; x1.

18-22. Ventral, dorsal, anterior, posterior, and lateral views of complete specimen, GSC 63444, GSC locality 36777; x1.

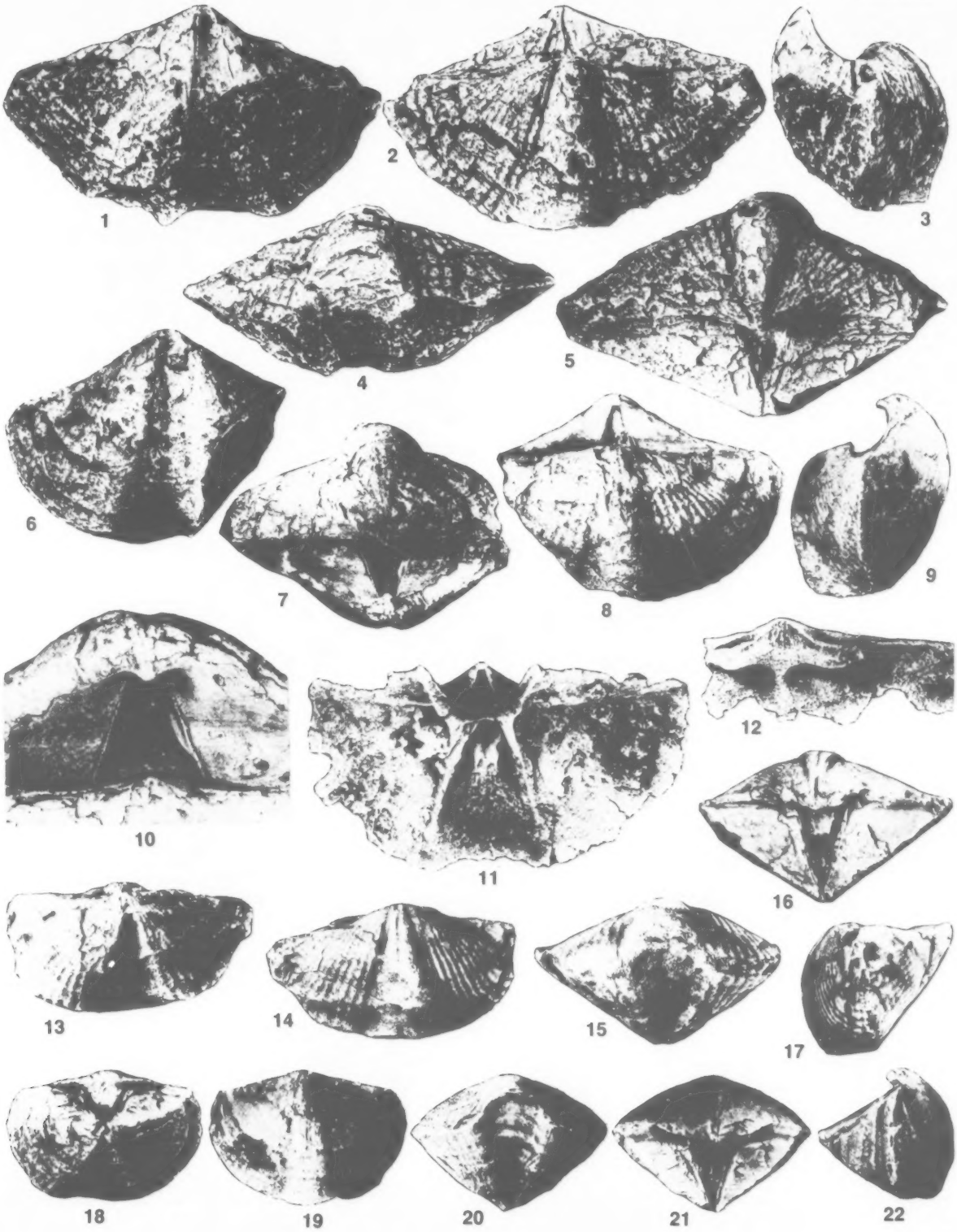
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PLATE 29

Figures 1-8. *Beecheria chouteauensis* (Weller) (Page 94)

1-5. Ventral, dorsal, lateral, anterior, and posterior views of a complete, slightly crushed shell, GSC 63454, GSC locality C-86543; x1.

6-8. Dorsal, anterior, and lateral views of a small specimen, GSC 63455, GSC locality 66117; x2.

Figures 9-14. *Beecheria* cf. *B. chouteauensis* (Weller) (Page 94)

Ventral, dorsal, and lateral views of two silicified specimens, GSC 10086a and 10086b, respectively, GSC locality 18293; x1.

Figures 15-18. *Dielasma* sp. A (Page 89)

Ventral, dorsal, lateral, and anterior views, GSC 63452, GSC locality 37131; x2.

Figures 19-23. *Dielasma* sp. B (Page 89)

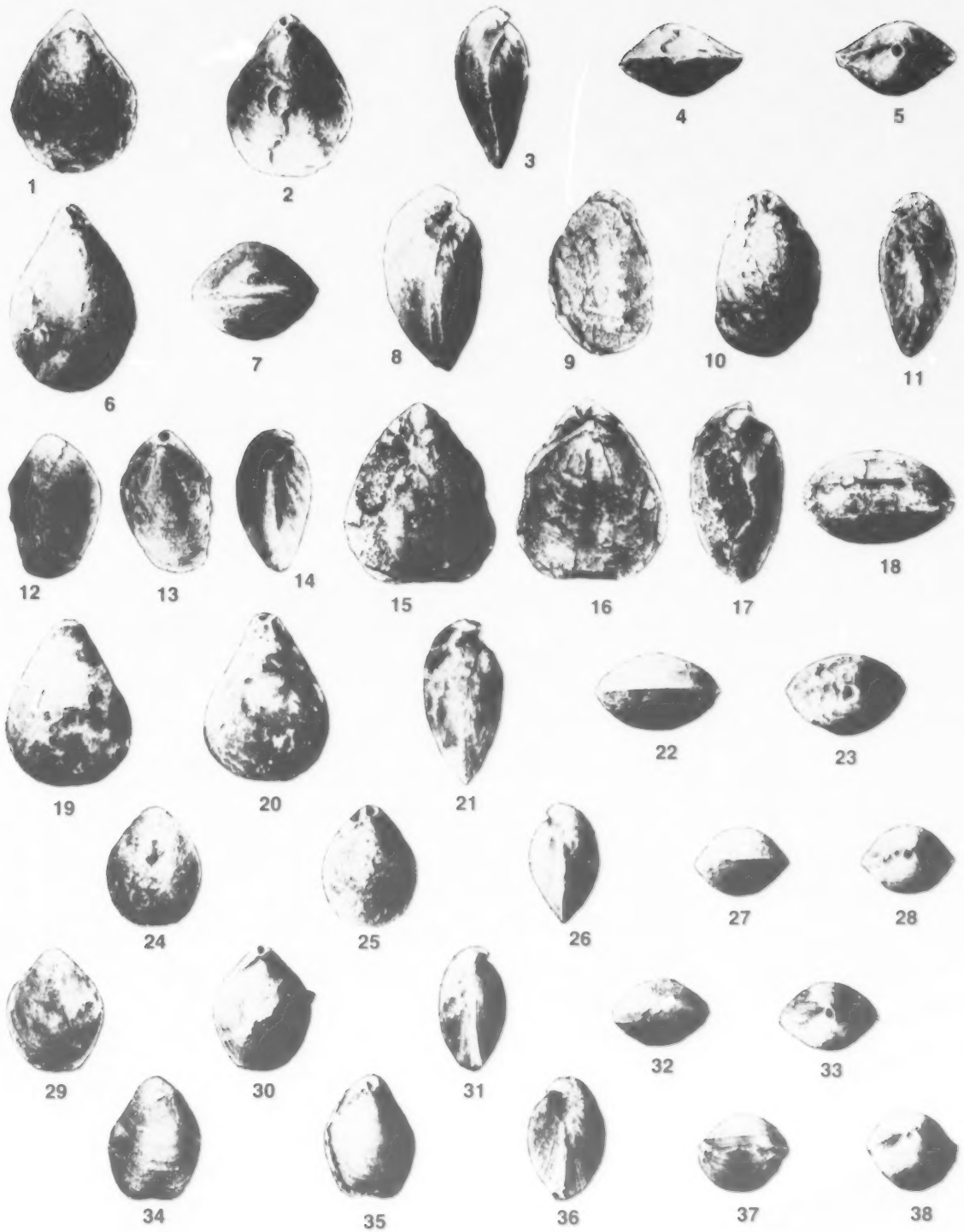
Ventral, dorsal, lateral, anterior, and posterior views, GSC 63453, GSC locality 68573; x3.

Figures 24-38. *Cranaena* cf. *C. texana* Carter (Page 89)

24-28. Ventral, dorsal, lateral, anterior, and posterior views of three complete shells, GSC 63449; x2.

29-33. Ventral, dorsal, lateral, anterior, and posterior views of complete shell, GSC 63450, GSC locality 19992; x2.

34-38. Ventral, dorsal, lateral, anterior, and posterior views of complete shell, GSC 63451, GSC locality 74866; x2.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